ICT4D Action Research in EWS

over the past decade plus

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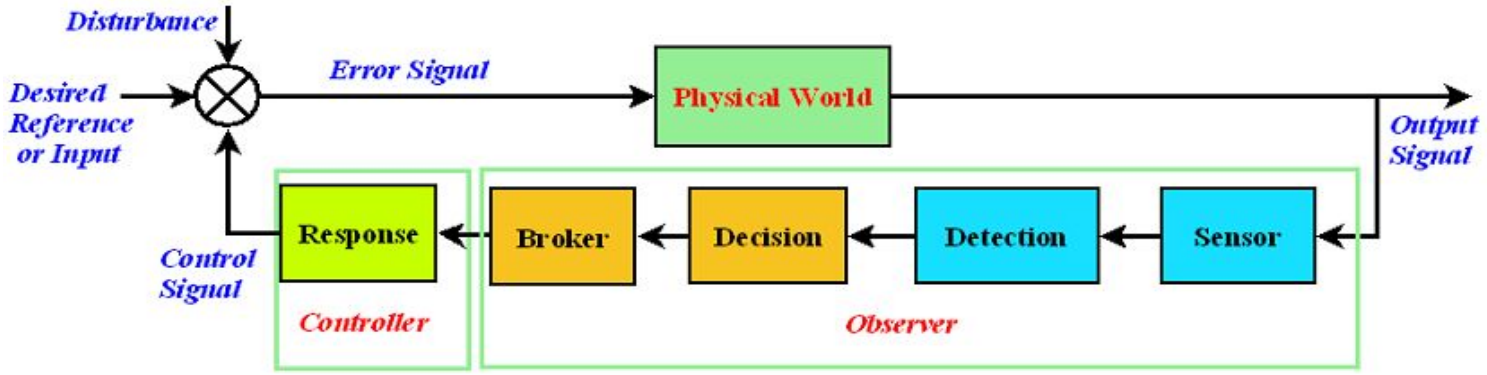
Outline

- Doctrine
- Community-centered EWS
- Role of ICTs in EWS
- Real-Time Biosurveillance
- Voice-enabled ICTs in Em Comm
- HazInfo Project
- EWS Classification
- Future work

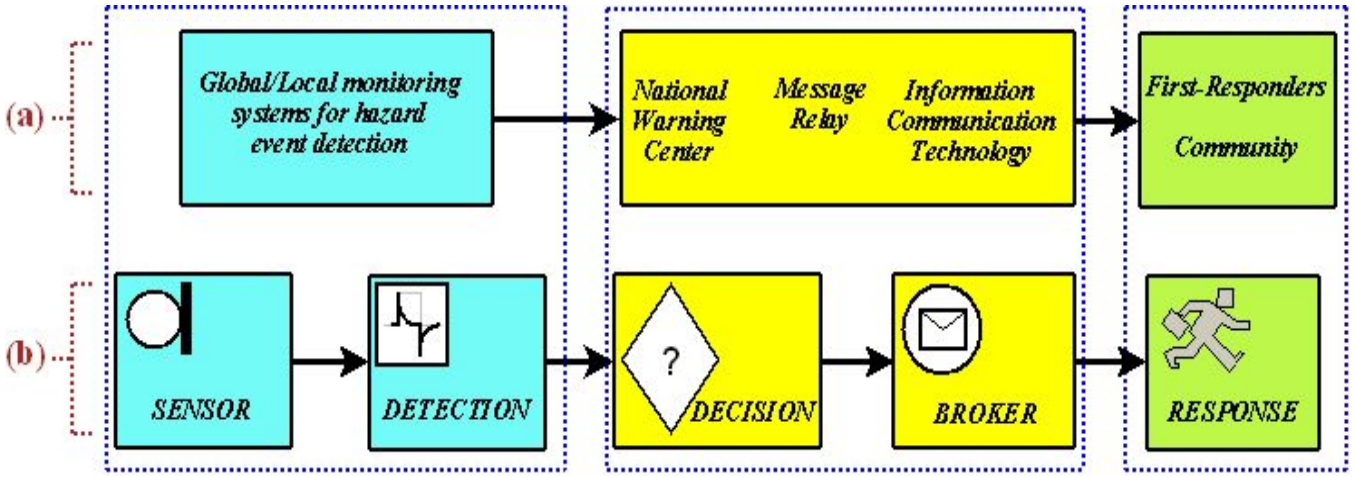
DOCTRINE

Definition of an Early Warning System



Definition: "*Early Warning System* (EWS)": A chain of information communication systems comprising sensor, detection, decision, and broker subsystems, in the given order, working in conjunction, forecasting and signalling disturbances adversely affecting the stability of the physical world; and giving sufficient time for the response system to prepare resources and response actions for minimizing the impact on the stability of the physical world.

- Waidyanatha, "Towards a Typology of Functional Early Warning Systems, 2010



Wikipedia definition

https://en.wikipedia.org/wiki/Early_warning_system

Early warning system

From Wikipedia, the free encyclopedia

Early warning is a major element of disaster risk reduction. It prevents loss of life and reduces the economic and material impact of disasters. To be effective, **early warning systems** need to actively involve the communities at risk, facilitate public education and awareness of risks, effectively disseminate alerts, and warnings and ensure there is constant state of preparedness.[1] A complete and effective early warning system supports four main functions: risk analysis,[*disambiguation needed*] monitoring and warning; dissemination and communication; and a response capability.[2]

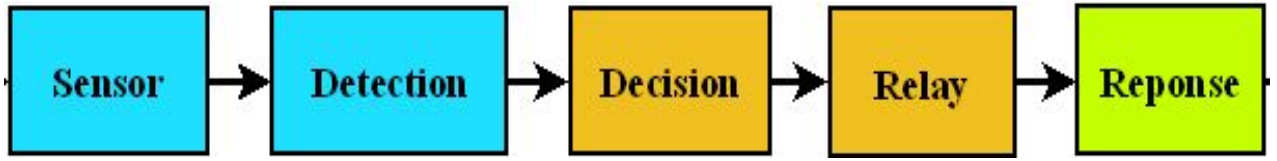
Risk analysis involves systematically collecting data and undertaking risk assessments of predefined hazards and vulnerabilities. Monitoring and warning involves a study of the factors that indicate a disaster is imminent, as well as the methods used to detect these factors. Dissemination and communication concerns communicating the risk information and warnings to reach those in danger in a way that is clear and understandable. Finally, an adequate response capability requires the building of national and community response plan, testing of the plan, and the promotion of readiness to ensure that people know how to respond to warnings.

An early warning system can be implemented as a chain of information communication systems and comprises sensors, event detection, decision support, and message broker subsystems. They work together to forecast and signal disturbances that adversely affect the stability of the physical world, providing time for the response system to prepare for the adverse event and to minimize its impact.[3]

An early warning system is more than a warning system, which is simply a means by which an alert can be disseminated to the public.

Since the Indian Ocean tsunami of 26 December 2004, there has been a surge of interest in developing early warning systems.[4][5] However, early warning systems can be used to detect a wide range of events, such as vehicular collisions, missile launches, disease outbreaks, and so forth. See warning system for a wider list of applications that can be also be supported by early warning systems.

Leopard EWS in the Animal Kingdom



All photographs by Dr. Sawan Waidyanatha

Sensor: Grey Langa scan the surrounding for threats

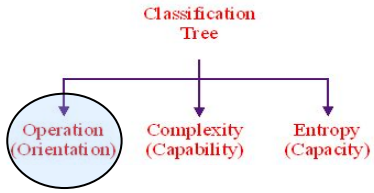
Detection: they see a Leopard approaching and begin screaming

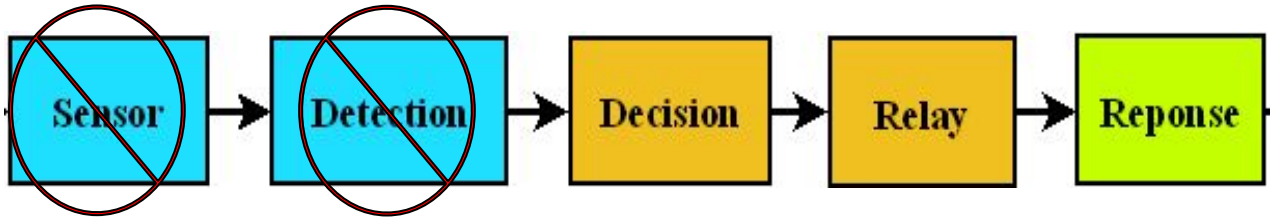
Decision: the Chital Buck (decision maker) assesses the situation and alerts the pack

Relay: adult (mother) Chitals relay the threat to the rest of pack mostly the fauns

Response: 1) if time permits evacuate the areas or 2) form a semi circle tucking fauns between adults and bark at Leopard

Leopard EWS in the animal kinc

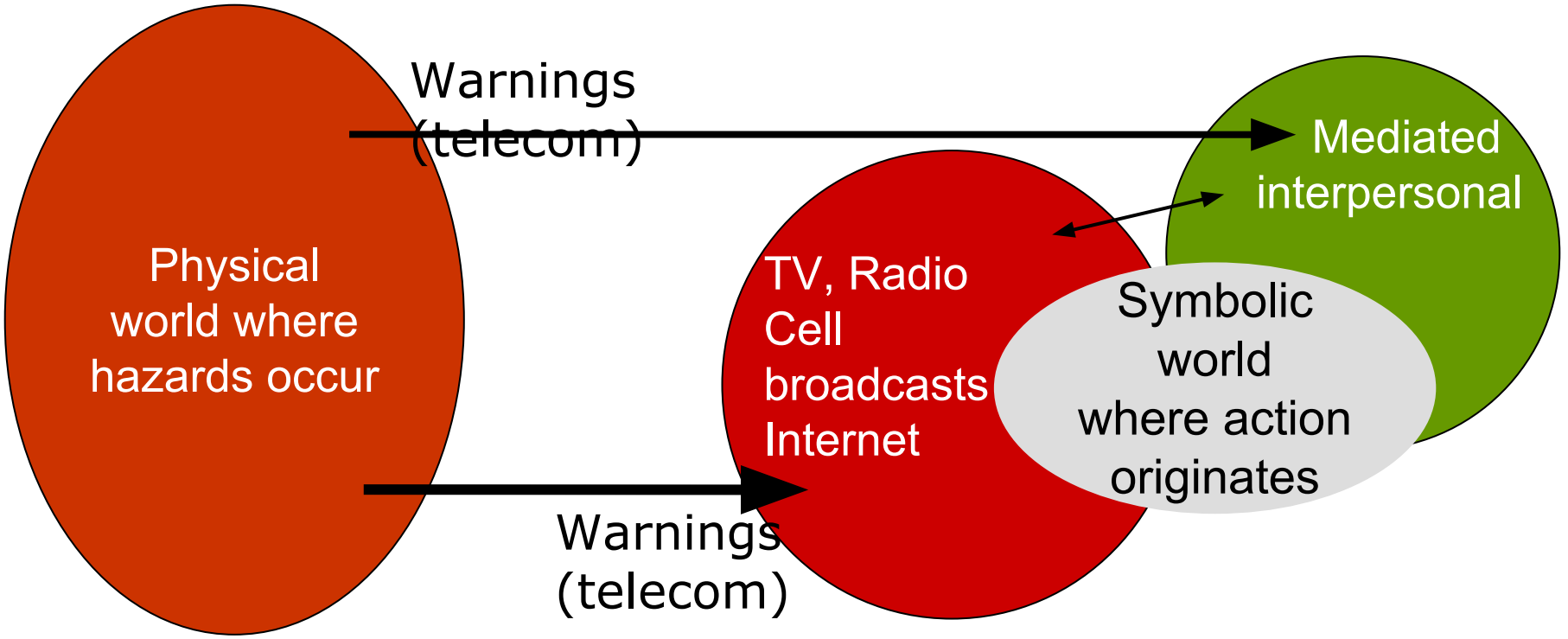




- In the open field there are no Gray Langa to sense and detect approaching threats
- out in the open system is weak
- all elements of the communication chain must coexist if system is to be effective

Proposition: "*EWS necessary and sufficient components*" Chain of Sensors, Detection, Decision, Broker, and Response are a necessary and sufficient components of an effective EWS.

How does ICT help?



The physical, the symbolic & their linking through ICTs, simplified **More time to run; more lives saved**

ICTs enable the linking of physical world within which hazards occur and symbolic world of the human likely to be harmed by those hazards, so that they may take life saving action. But the effective linking of these worlds requires not only ICTs, but also the existence of institutions that allow for the effective mobilization of their potential

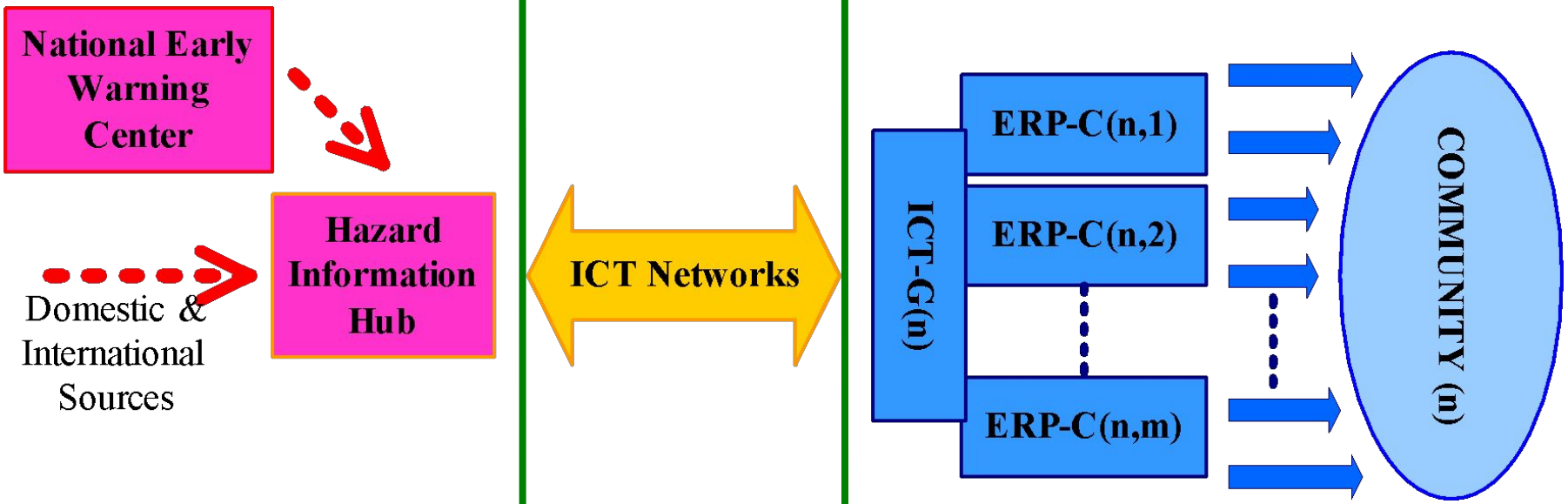
- Samarjiva: mobilizing ICTs for disaster warning, 2005

Discuss 4 Research Projects

- HazInfo Project
- Biosurveillance Project
- Voice-ICT in EM Comm
- ICT use in Agriculture

Last-Mile Hazard Warning System (HazInfo)

Last Mile Hazard Warning System (HazInfo Project)



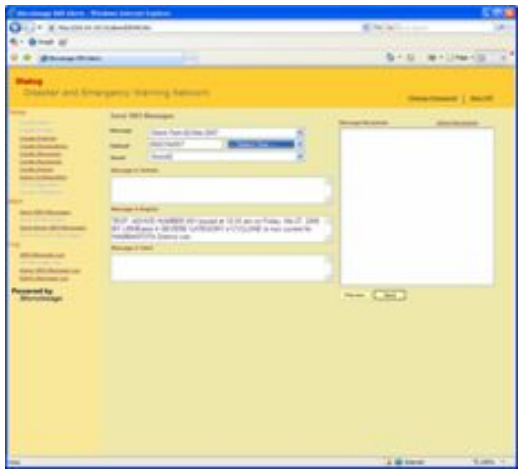
Sarvodaya Community Disaster Management Center (SCDMC)

Communications Providers

Sarvodaya Communities

Five Wireless ICTs

GSM



SAT Radio

Internet

CALL

Research Matrix

	With ERP Training			No ERP Training				
Sarvodaya Stage 1, 2, 3	**VSAT** Urawatha (Galle)	**MoP** Nidavur (Batticalo)	**FxP** Thirukadalar (Trincomalee)	**AREA** Moratuwella (Colombo)	**MoP** Meddhawatha (Matara)	**MoP** Thambiluvil (Kalmunai)	**FxP** Oluville (Kalmunai)	**AREA** Maggona (Kalutara)
	AREA + RAD Modarapallassa (Hambantota)	**AREA + FxP** Wathegama North (Matara)	**AREA + MoP** Palmunnai (Batticalo)	Control Village Abeyasinghepura (Ampara)	**AREA + RAD** Thondamanar (Jaffna)	**AREA + FxP** Karathivu (Kalmunai)	**AREA + MoP** Munnai (Jaffna)	Control Village Modara (Colombo)
Sarvodaya Stage 4	**VSAT** Modaragama (Hambantota)	**MoP** Diyalagoda (Kalutara)	**FxP** Periyakallar (Batticalo)	**AREA** Panama North (Ampara)	**MoP** Satur-kondagnya (Batticallo)	**MoP** Samodhagama (Hambantota)	**FxP** Indivinna (Galle)	**AREA** Brahamana-wattha (Galle)
	AREA + RAD Kalmunai II (Kalmunai)	**AREA + FxP** Samudragama (Trincomalee	**AREA + MoP** Valhengoda (Galle)	Control Village Mirissa South (Matara)	**AREA + RAD** Venamulla (Galle)	**AREA + FxP** Kottegoda (Matara)	**AREA + MoP** Thallala South (Matara)	Control Village Thalpitiya (Kalutara)

AREA: Addressable Radio for Emergency Alerts, Class B configuration of WorldSpace System

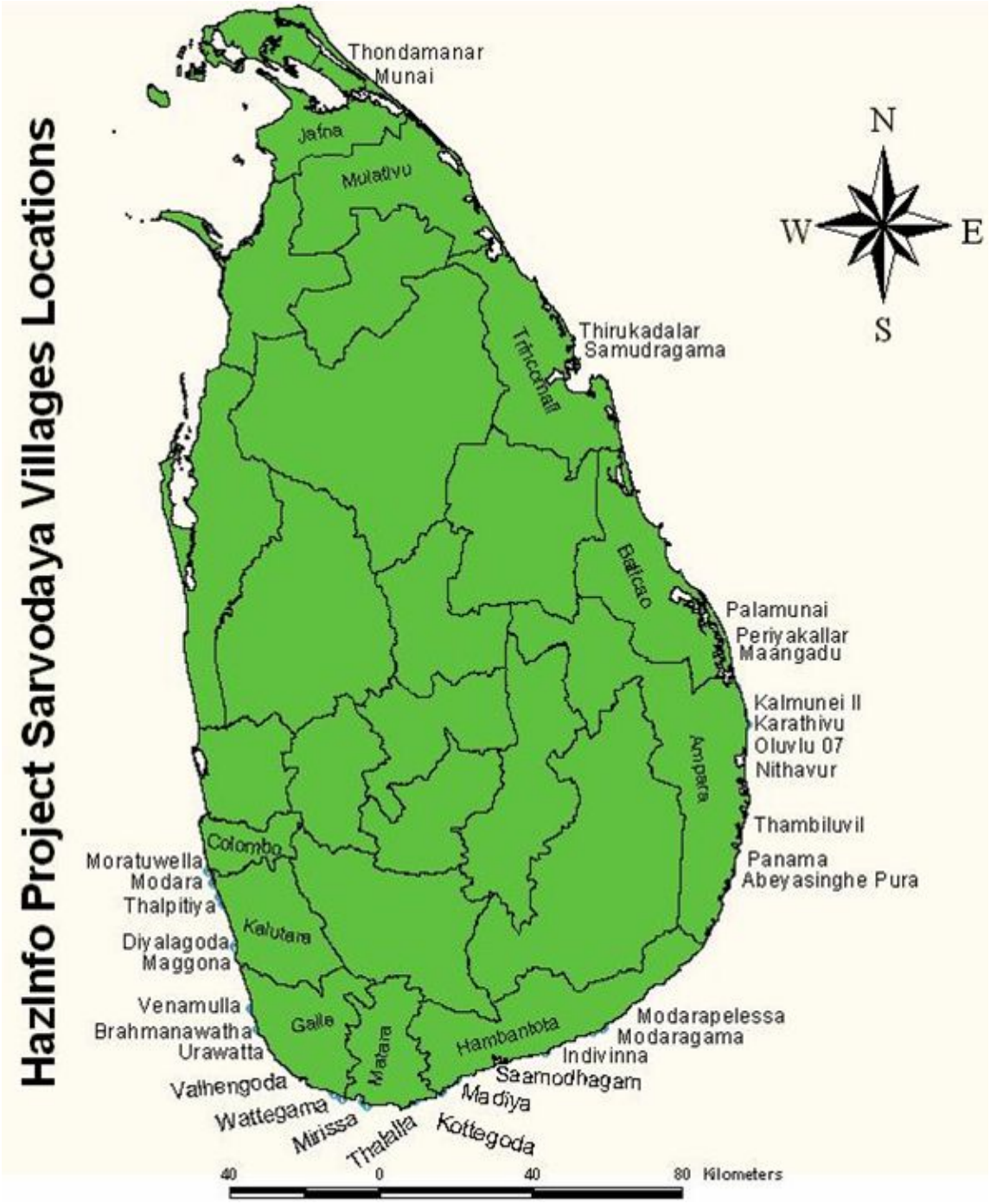
MoP: Java enabled Mobile Phone, Dialog-Microimage innovation DEWN application

RAD: Remote Alarm Device, Dialog-University-of-Moratuwa Innovation

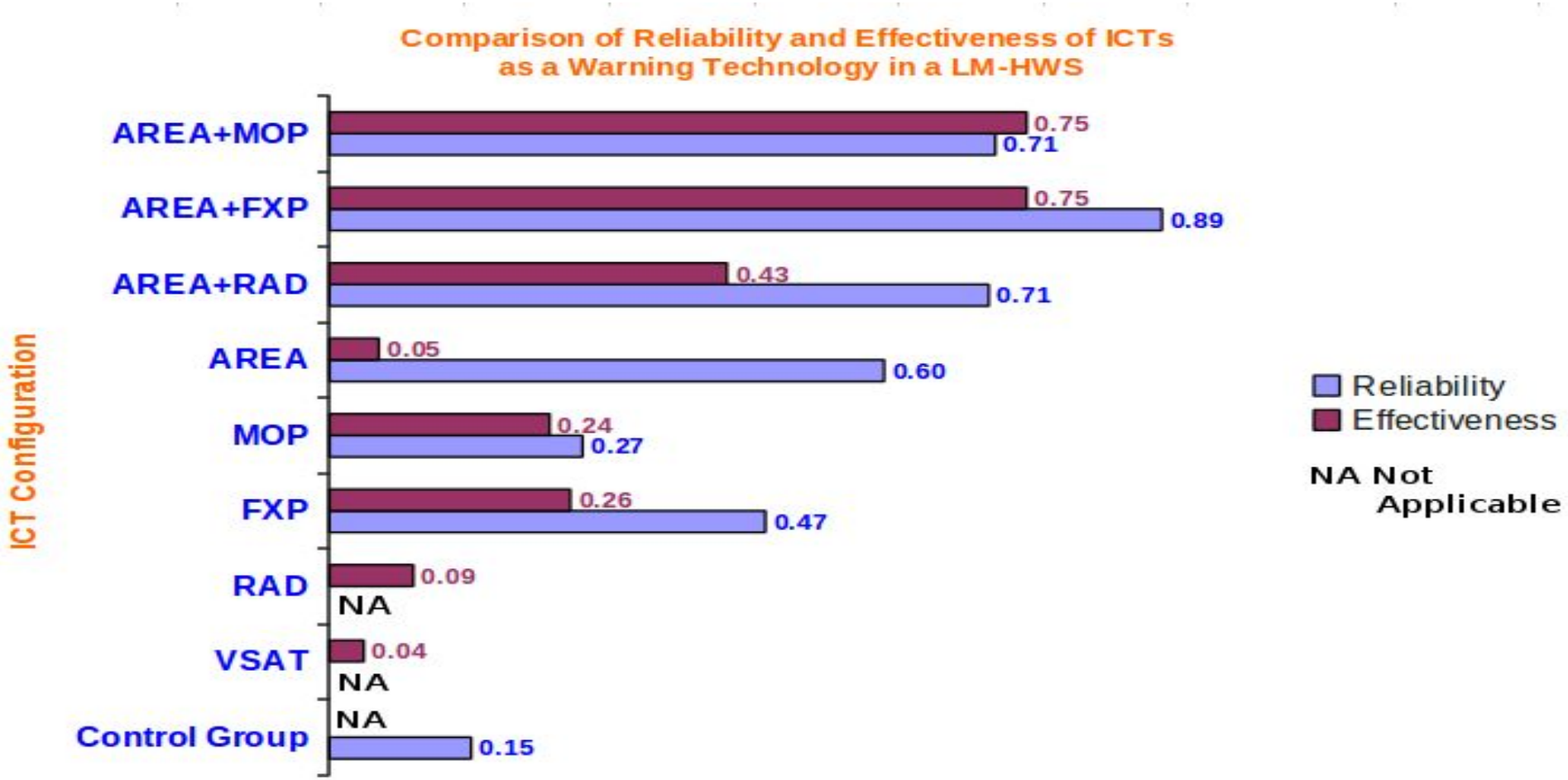
FxP: CDMA Wireless Fixed Phones with 1xRTT functions, Sri Lanka Telecom

VSAT: Very Small Aperture Terminals coupled with Internet Public Alerting System Innovative-Tech & Solana Networks

32 Tsunami Affected Coastal Villages

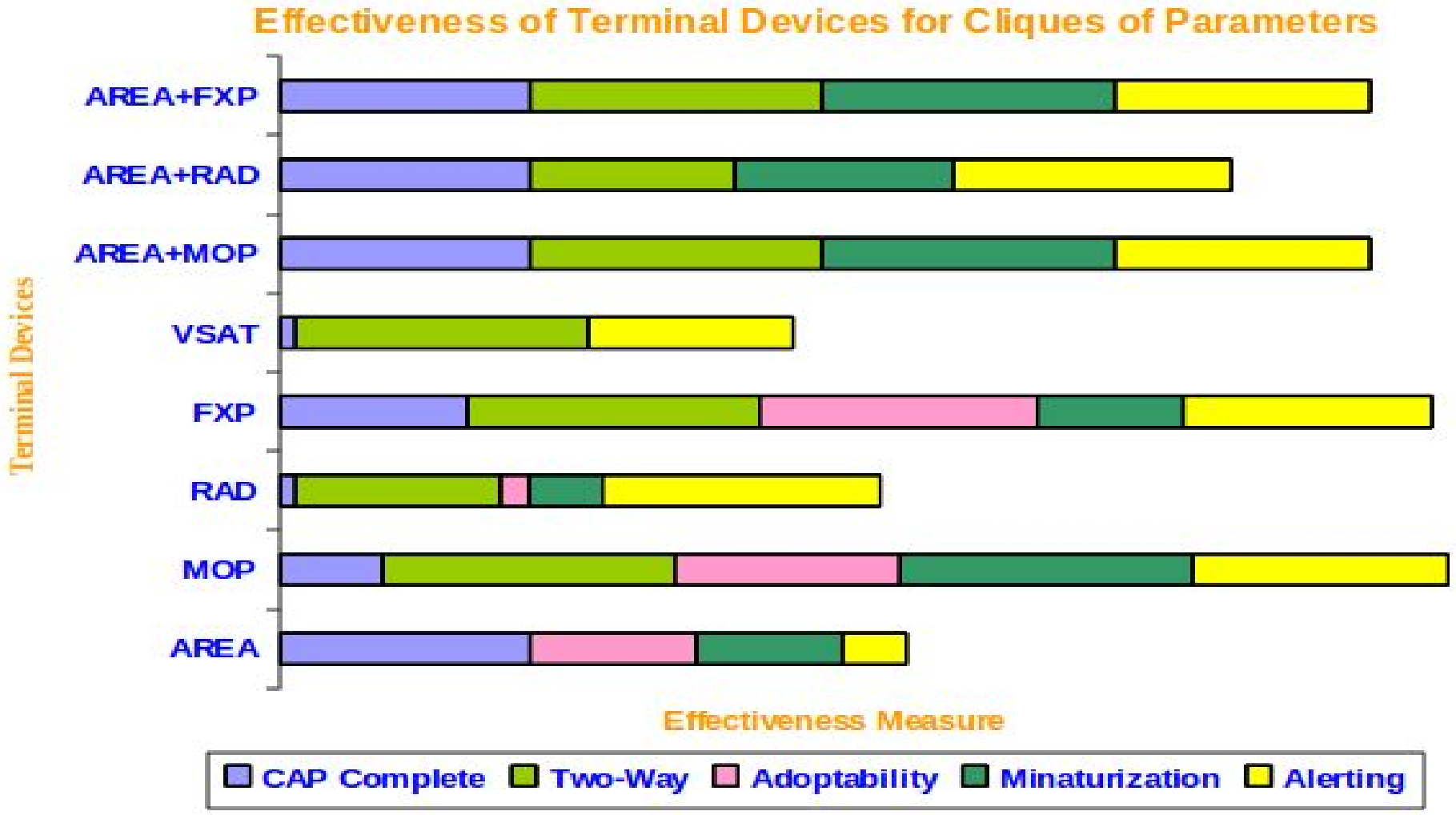


ICT Terminal Device Performance



Complementary Redundancy is a necessary condition - when paired ICTs perform than individuals

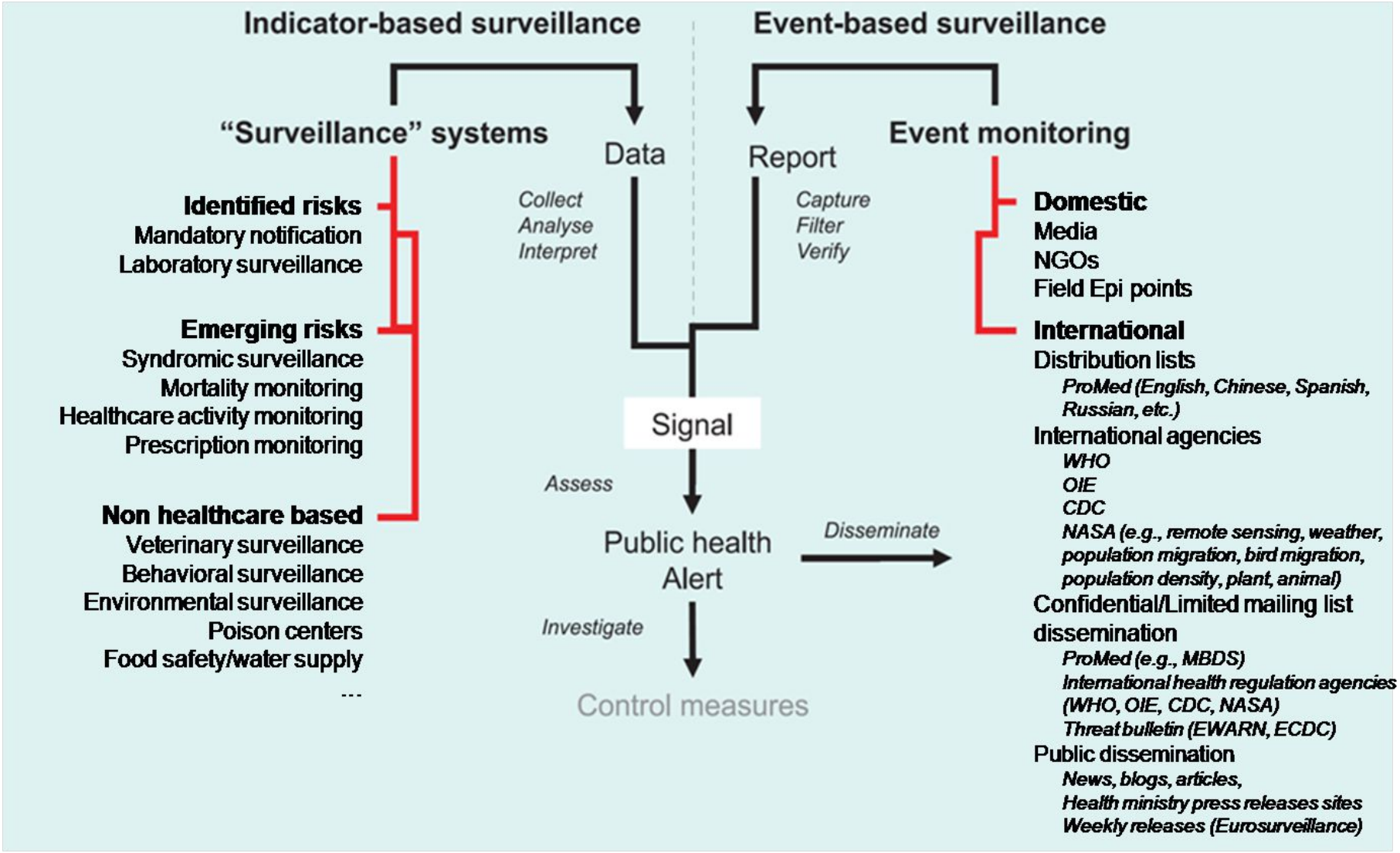
Effectiveness of the ICTs



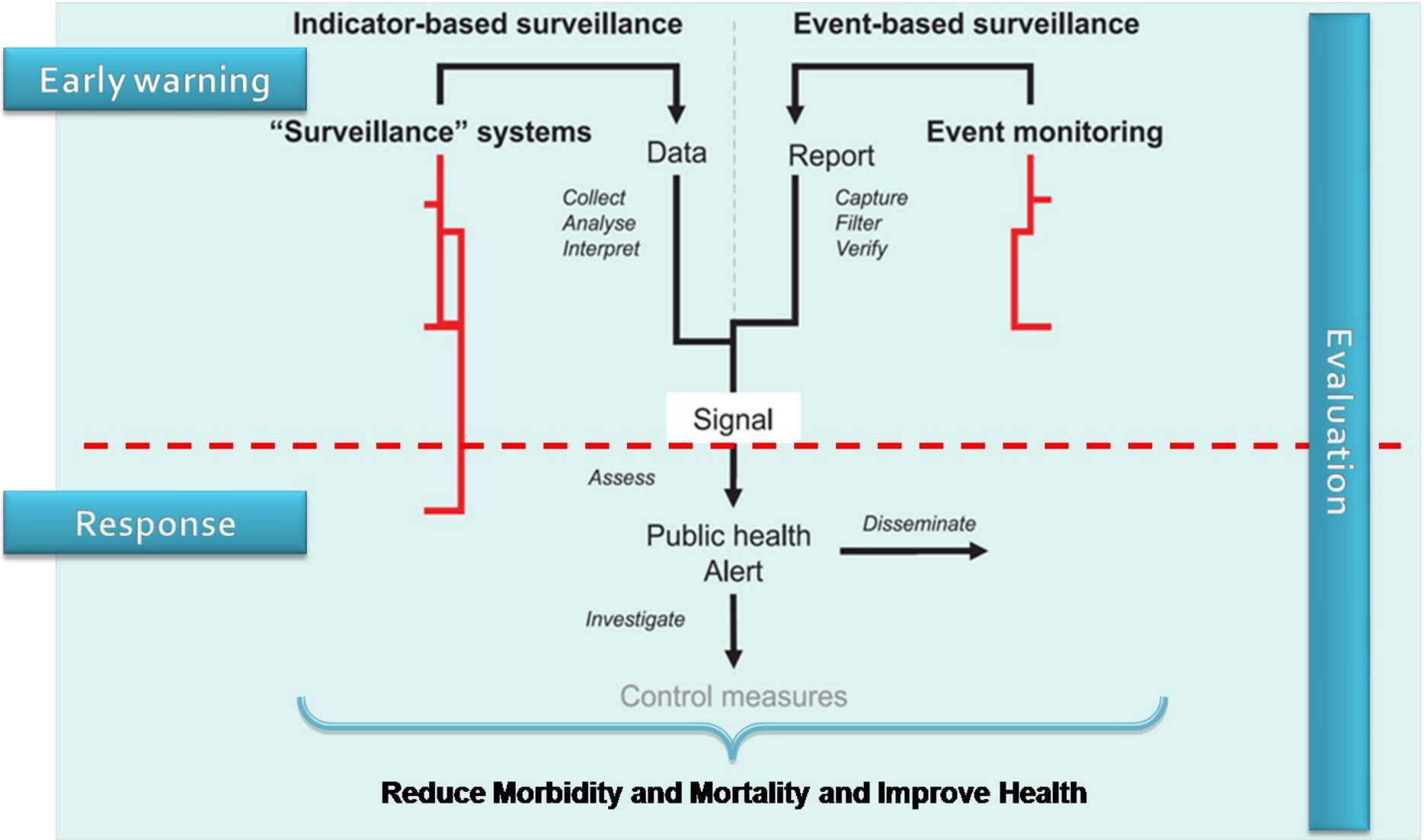
ICT bi-directionality, Integration into daily lives, affordability, interoperability, are necessary conditions

Real-Time Biosurveillance Program (m-Health)

Disease Surveillance & Notification

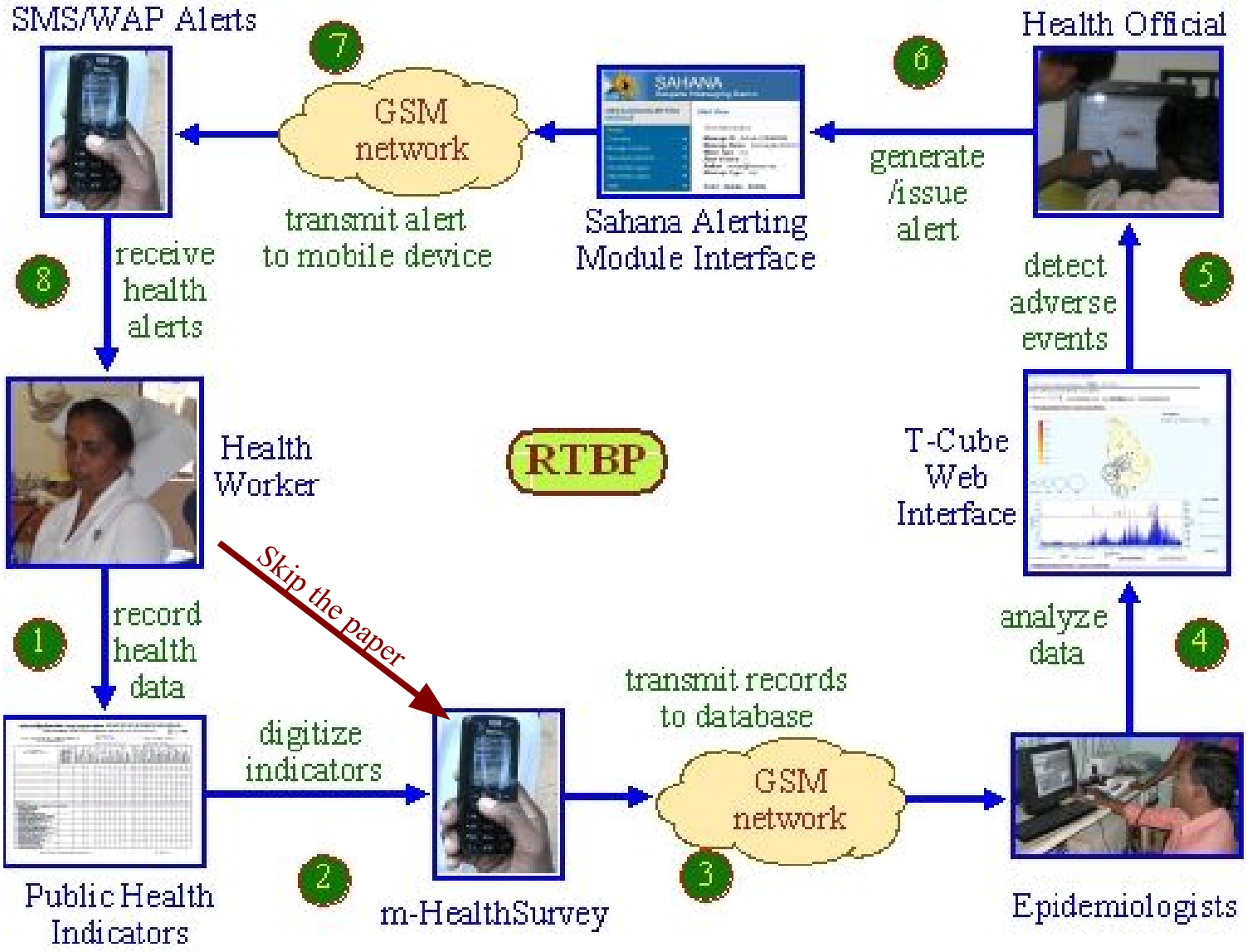


Disease Surveillance & Notification

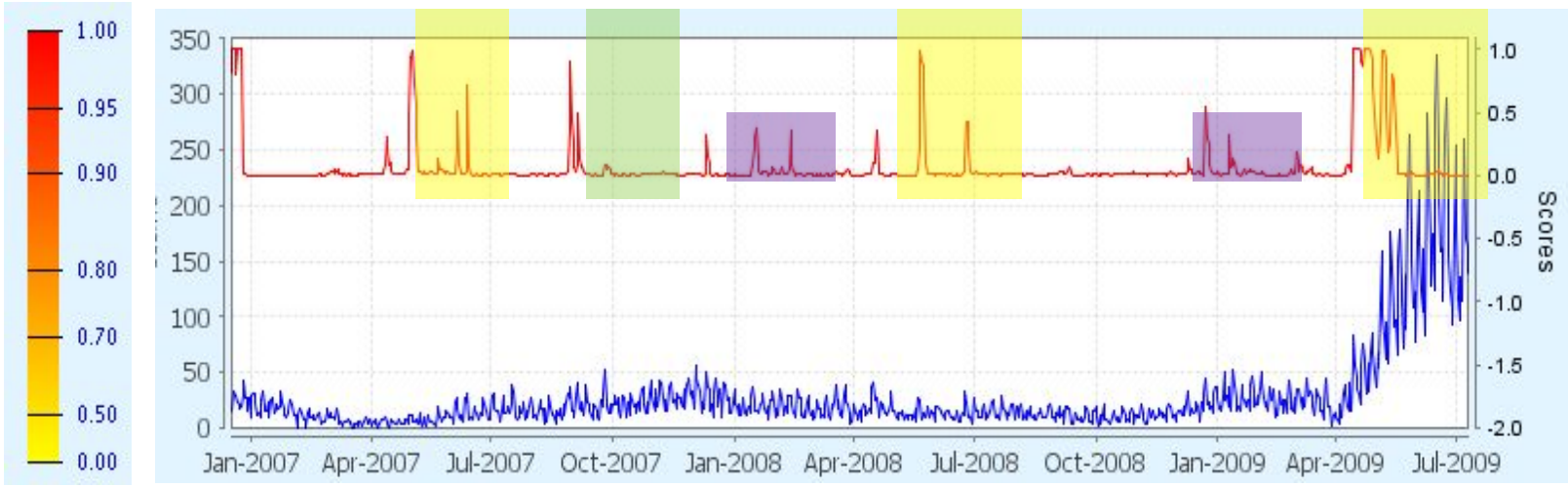


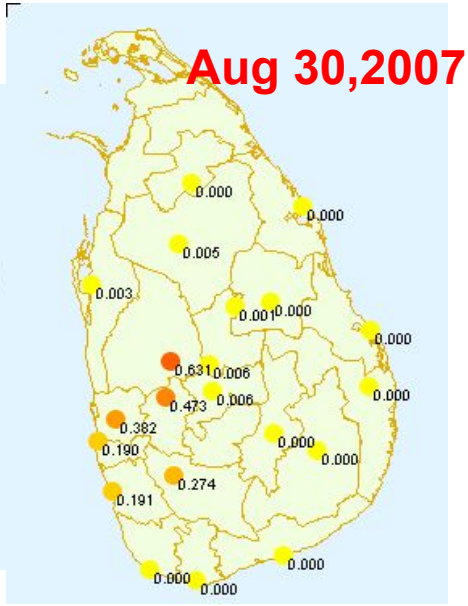
Real-Time Biosurveillance System

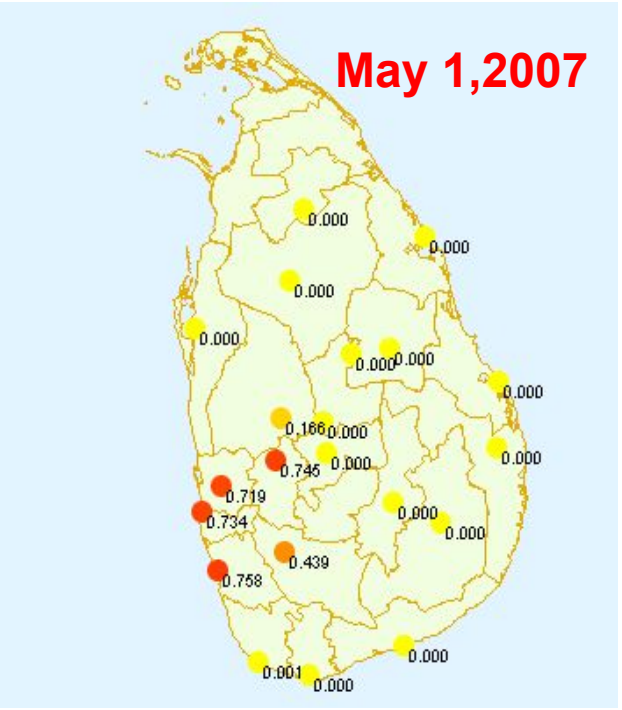
Actors, processes, and information flow of the proposed data collection, event detection, and situational-awareness/alerting real-time program

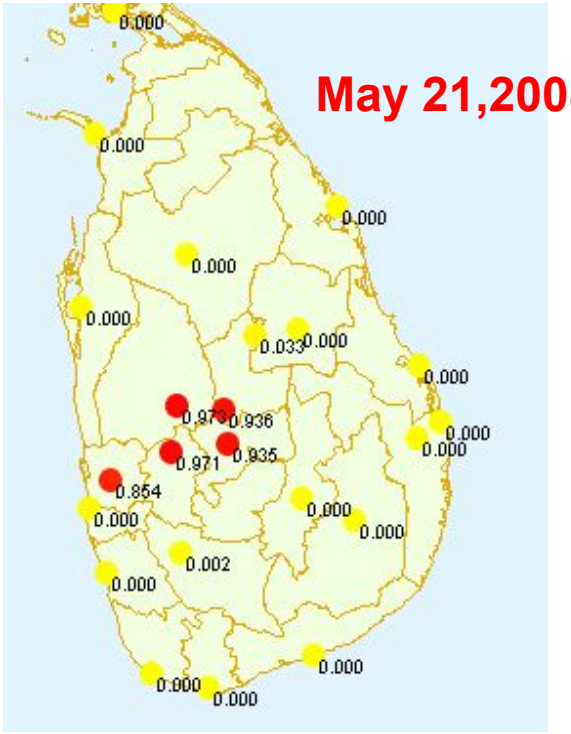


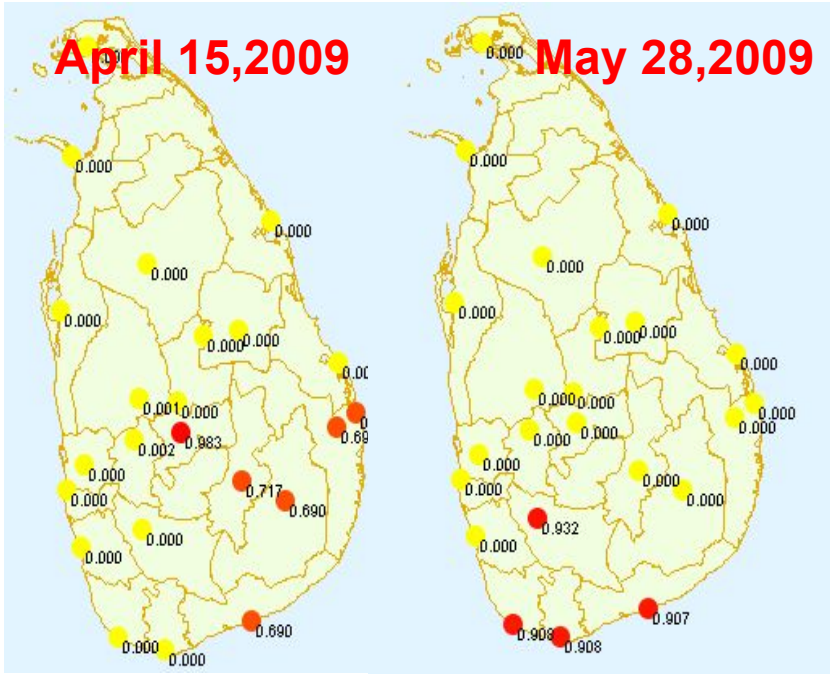
Dengue Fever Seasonal and spatial pattern



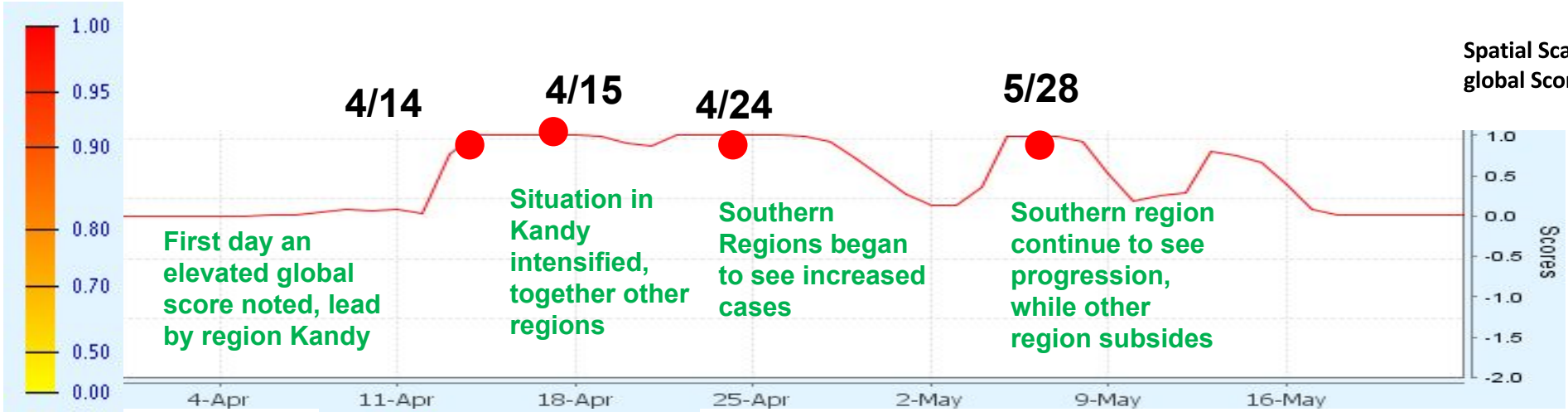


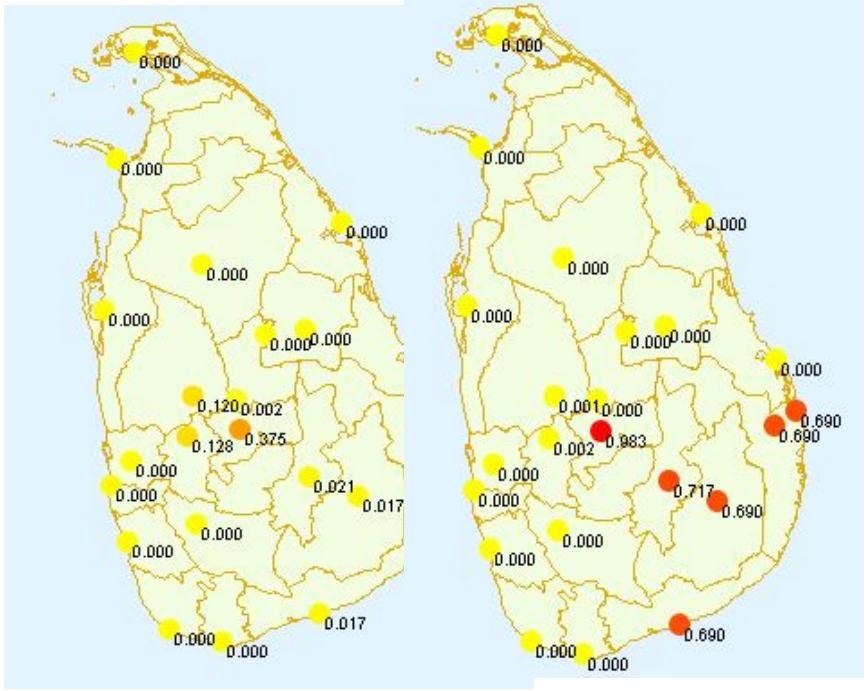


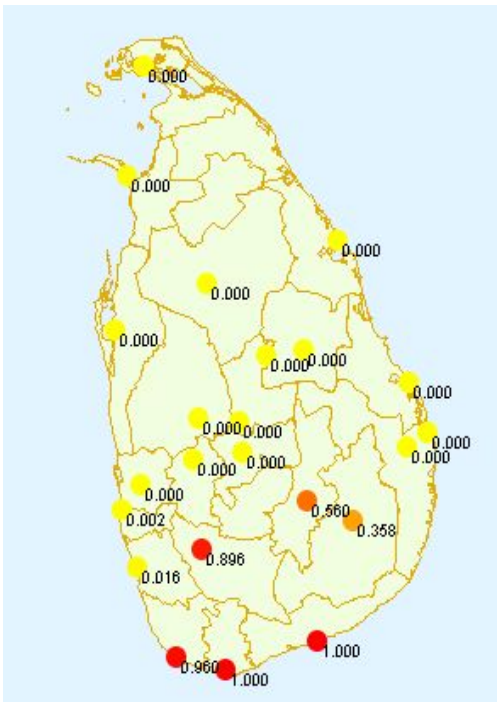


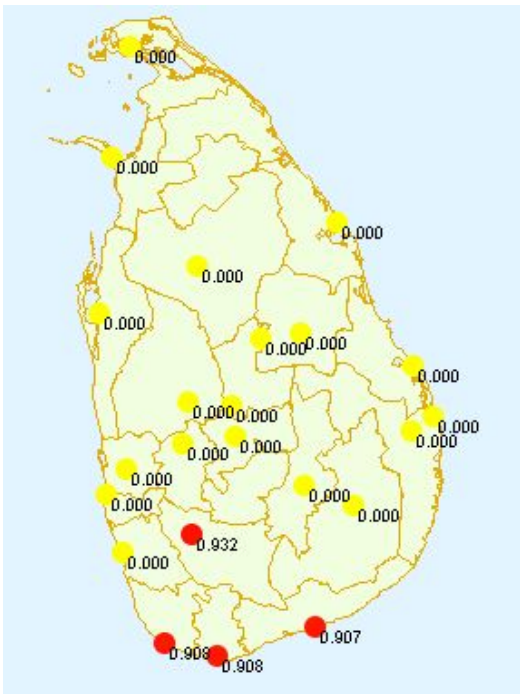


Progression of Dengue Fever outbreak in April – June 2009

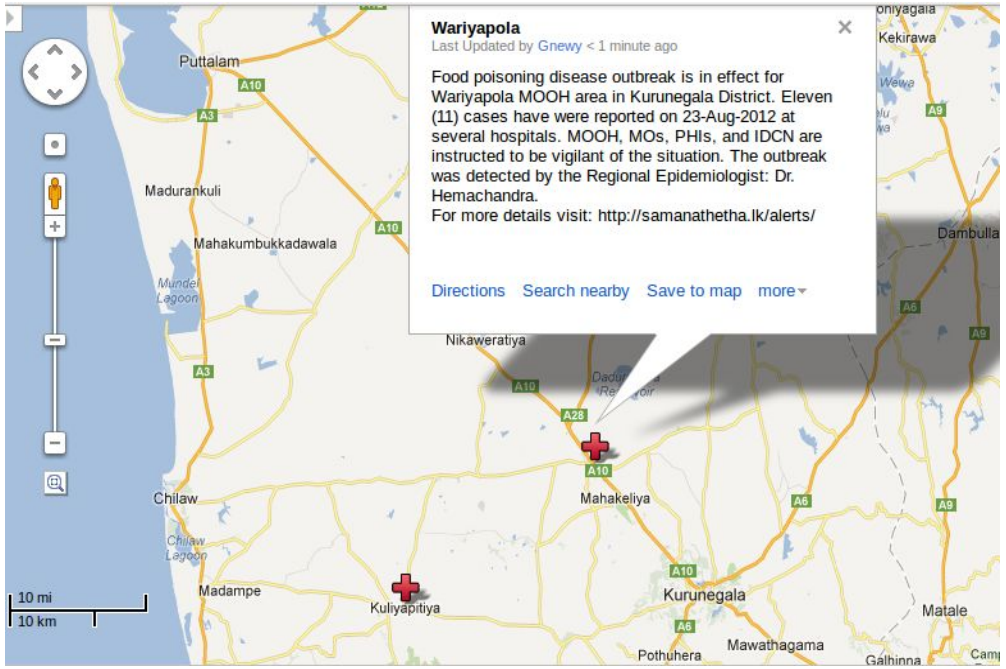


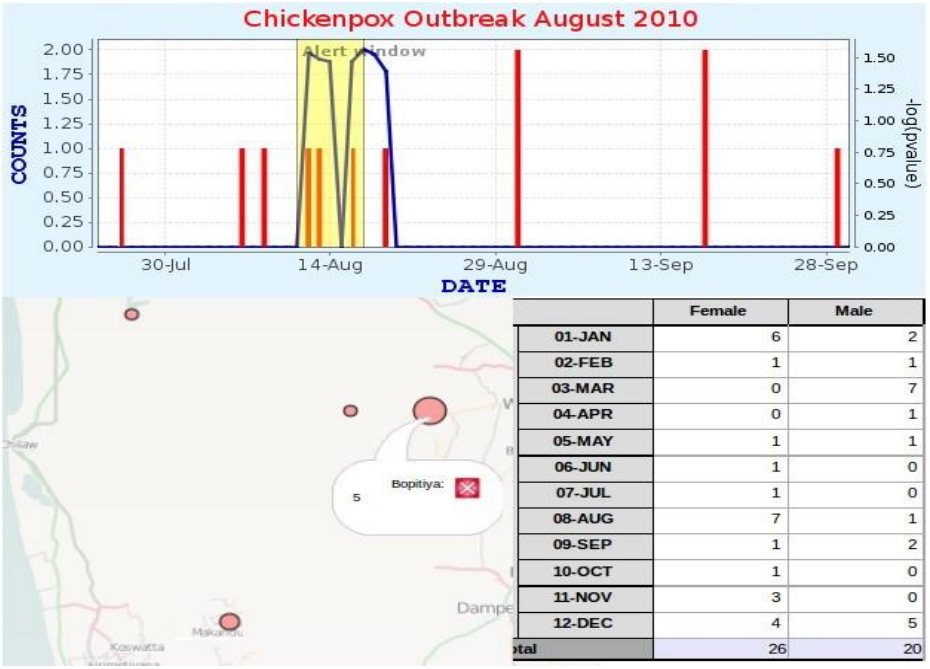




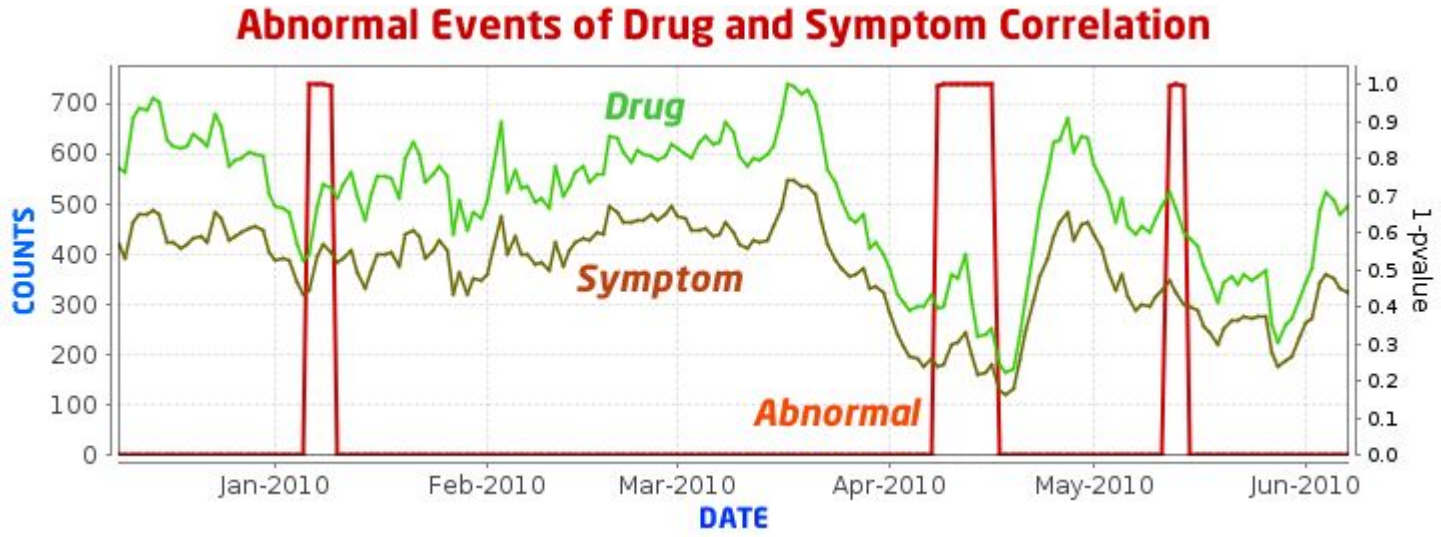


Real Events Detected in Pilot



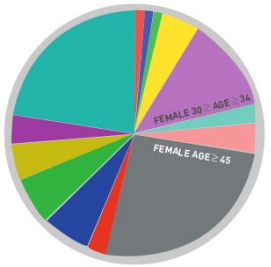


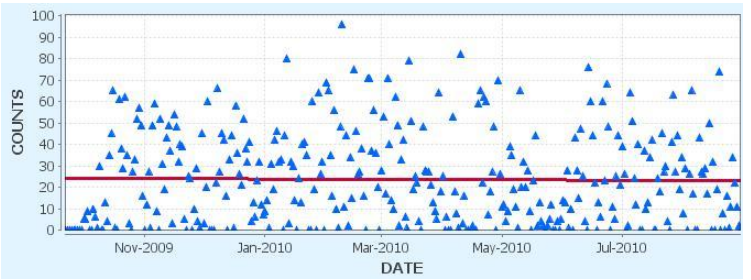
	Female	Male
01-JAN	6	2
02-FEB	1	1
03-MAR	0	7
04-APR	0	1
05-MAY	1	1
06-JUN	1	0
07-JUL	1	0
08-AUG	7	1
09-SEP	1	2
10-OCT	1	0
11-NOV	3	0
12-DEC	4	5
otal	26	20

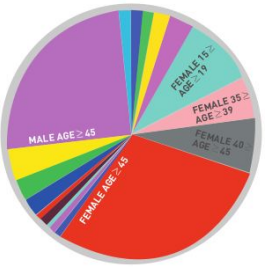


Trends in selected Chronic disease

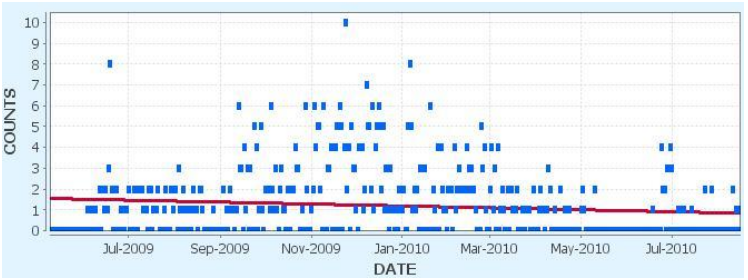
These findings are from TCWI's statistical estimation and pivot table analysis methods

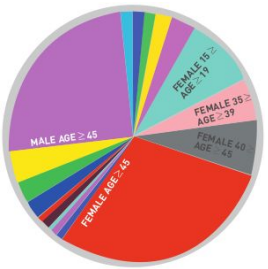


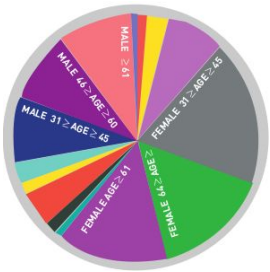




Arthritis and Rheumatoid-Arthritis has a linearly stagnate trend over the one year period in both countries with Males over 45 years of age and Females over 35 years of age to be the most susceptible in India; similarly Males over 45 and Females over 31 years of age to be the most vulnerable groups.



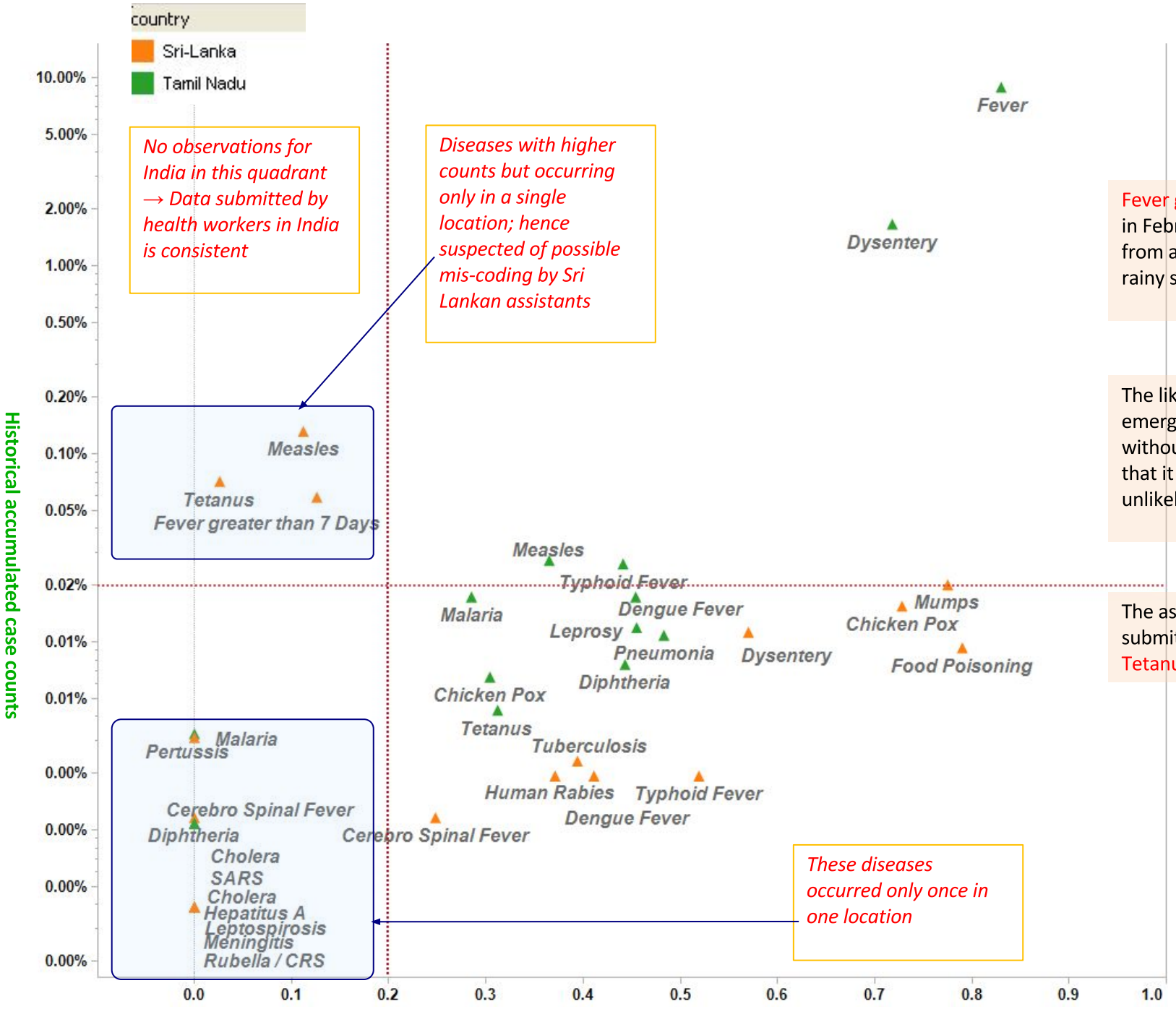




Asthma has a linearly decreasing trend over the one year period in both countries; the dtrend shows the counts to increase during the rainy season, India: Sept'09-Jan'10 and Sri Lanka: Nov '09-Jan '10. In India, only males over 45 years of age are affected but females in all age groups are affected. Both Male and Female over 31 years of age are in Sri Lanka are equally vulnerable.

Given that the Male to Female ratios, approximately, in Tamil Nadu, India and Kurunegala, Sri Lanka are both 1 : 1; statistics to date show females to be more susceptible to the above mentioned life style diseases.

Observations of the data digitizing uncertainties



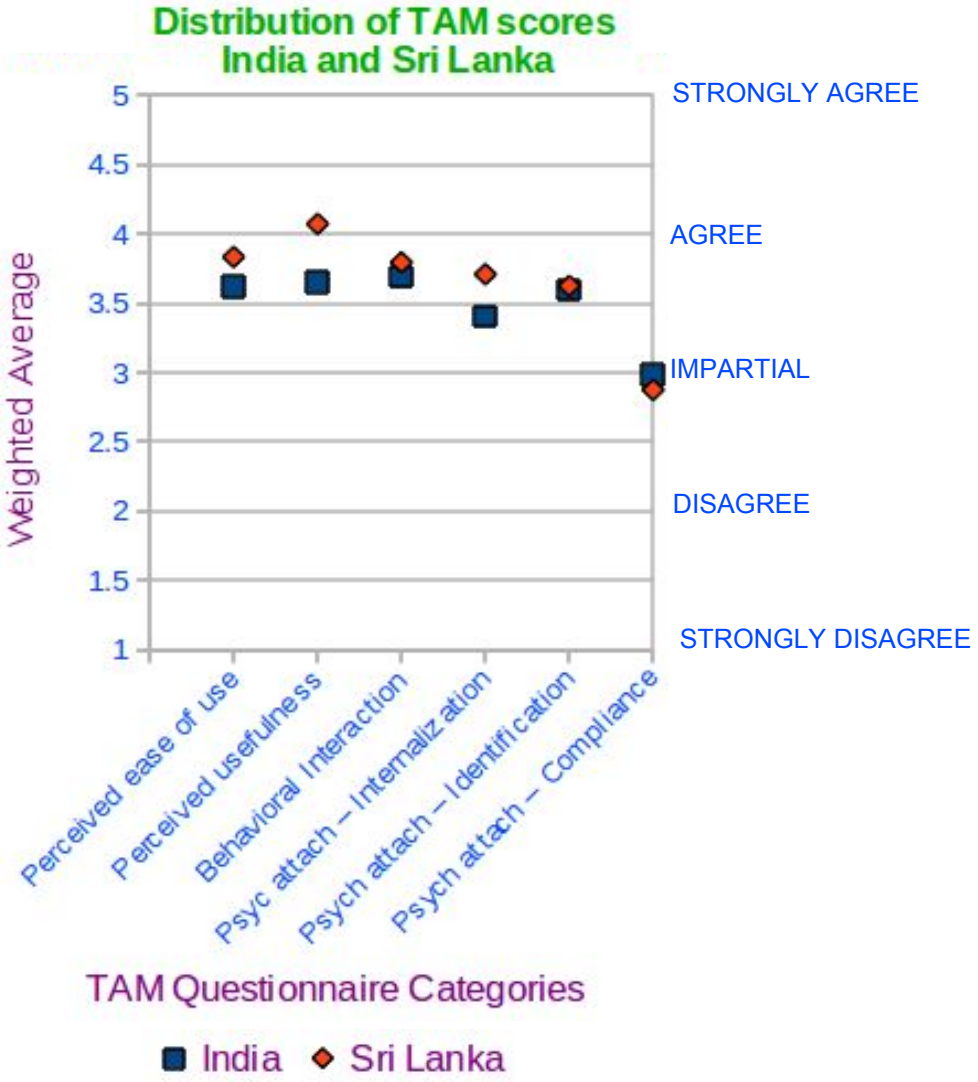
Fever greater than 7 days concentrated in February and March of 2010, mainly from a single location, during the non rainy season

The likelihood of a measles outbreak emerging only in a single location without spreading to other areas, given that it is a viral disease, is highly unlikely.

The assistant entering the data had submitted data for “Toxide vaccine” as Tetanus.

CMU's TCWI Technology Assessment Model scores

Technology Acceptance Model was applied to obtain these results on perceived ease of use, perceived usefulness, behavioral interaction, attitude towards using, and psychological attachment



Users attitude towards using TCWI

INDIAN

This part of the questionnaire was not completed.

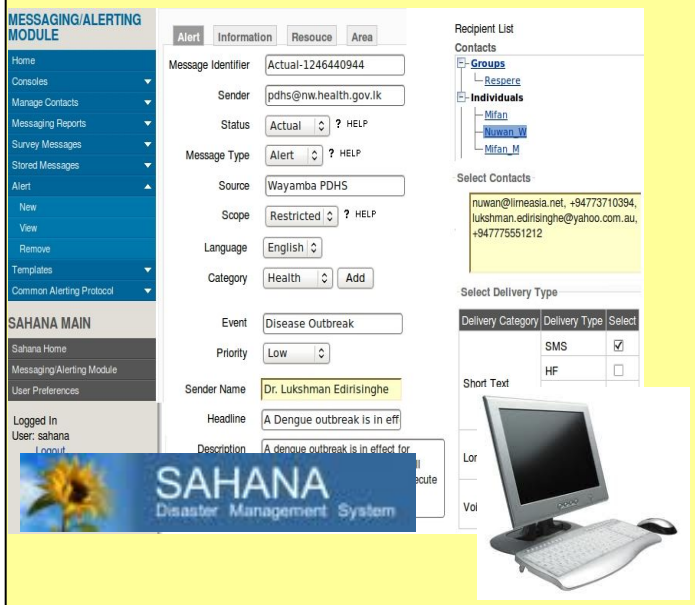
SRI LANKN

The personal feeling is such that, all things considered, TCWI in the job is - ***quite a good idea, slightly beneficial, quite a wise idea, and slightly positive***

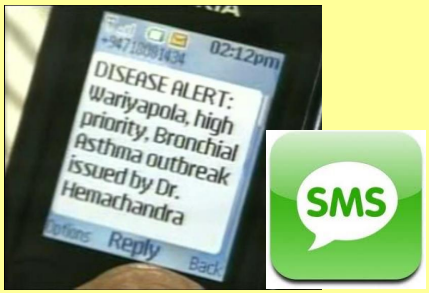
The TAM questionnaire was conducted with 14 Indian and 09 Sri Lankan users (health officials and health workers)

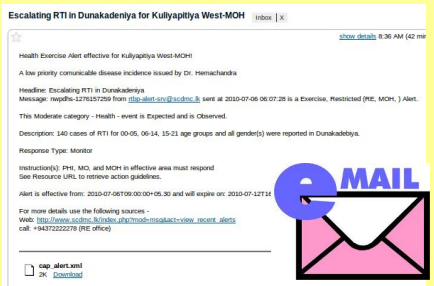
CAP short/long text Message delivery methods

Government
Regional Epidemiology and Medical Officer of Health departments

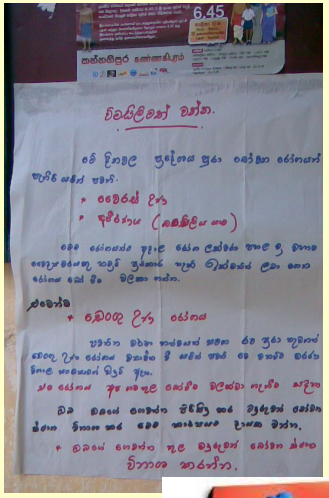


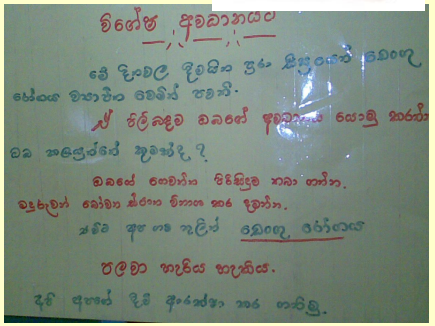
Government
Regional Epidemiology and Medical Officer of Health departments





Community
Suwadana Health Centers



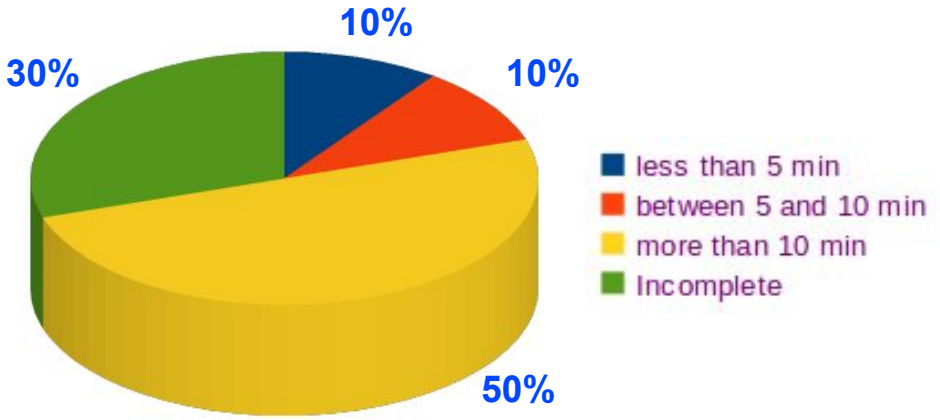


Single Input Multiple Output Mass Messaging; towards a publisher subscriber model

Messaging exercises with Sahana Alerting Broker

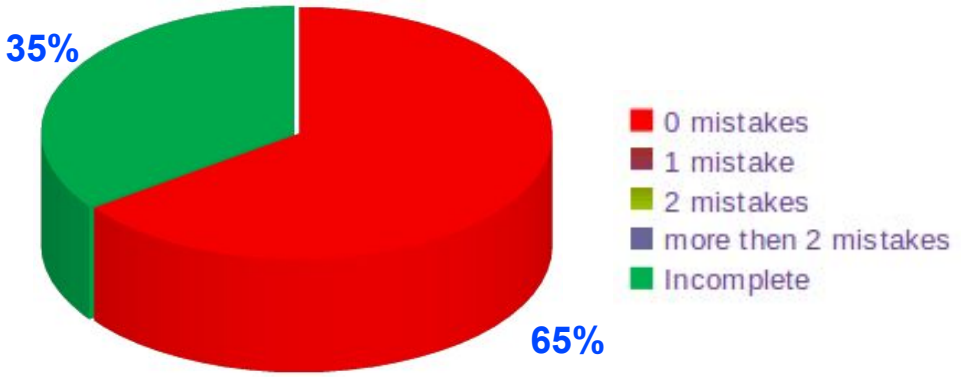
3 users in India and 5 users in Sri Lanka participated in the message dissemination exercises. Each user was presented with four varying scenarios in relation to escalating cases of diseases identified through TCWI and other sources.

Percentage of messages sent on-time (benchmark time-to-completion was 5 minutes)



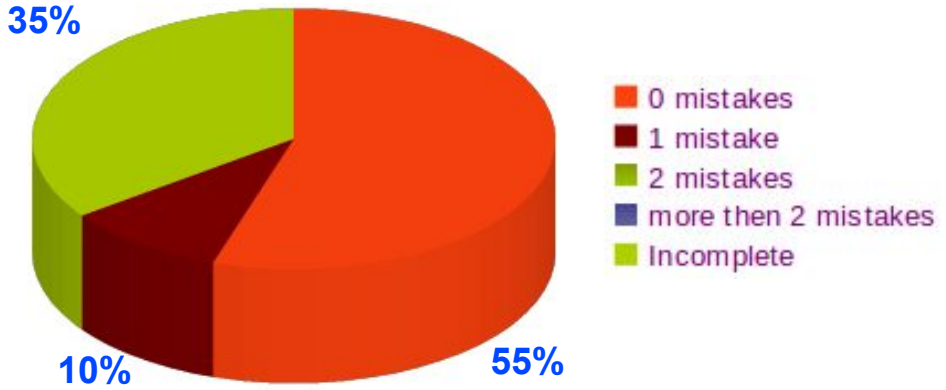
The security policy of the software, by default, is set to expire the session after 5 minutes to prevent unauthorized use, which forced the user to restart.

Accuracy of creating the messages with populating the common alerting protocol attributes of the software



Templates with pre-populated values and a clear structure helped the users with creating the messages

Correctly selecting the appropriate delivery channels targeting the intended recipients

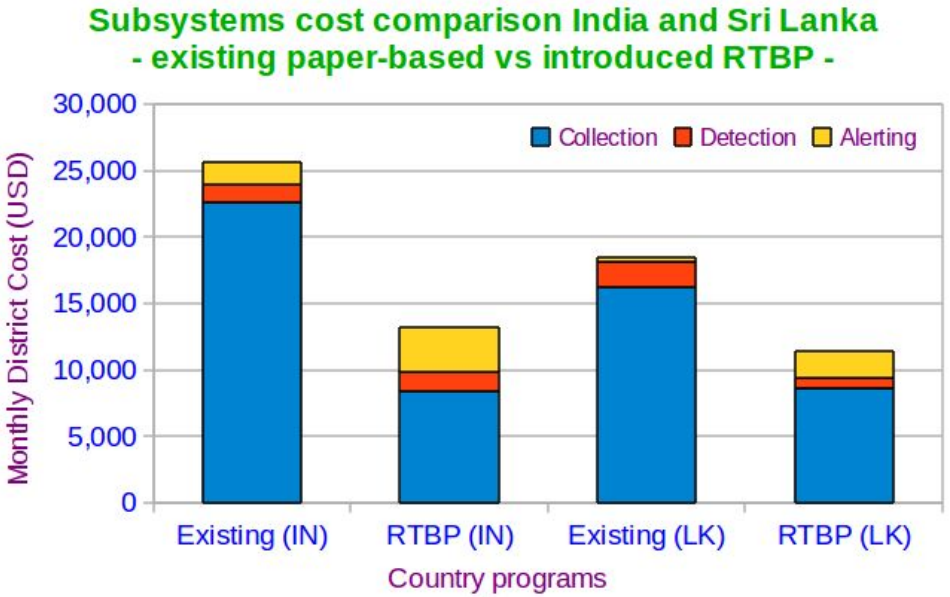


It was easier to comprehend issuing of alerts but not the the same with issuing situational awareness messages such as the weekly top 5 diseases reports.

INDIA Exercises were incomplete; no results to discuss

Total Cost of Ownership

Comparison of expenses in relation to the data collection, event detection, and alerting components

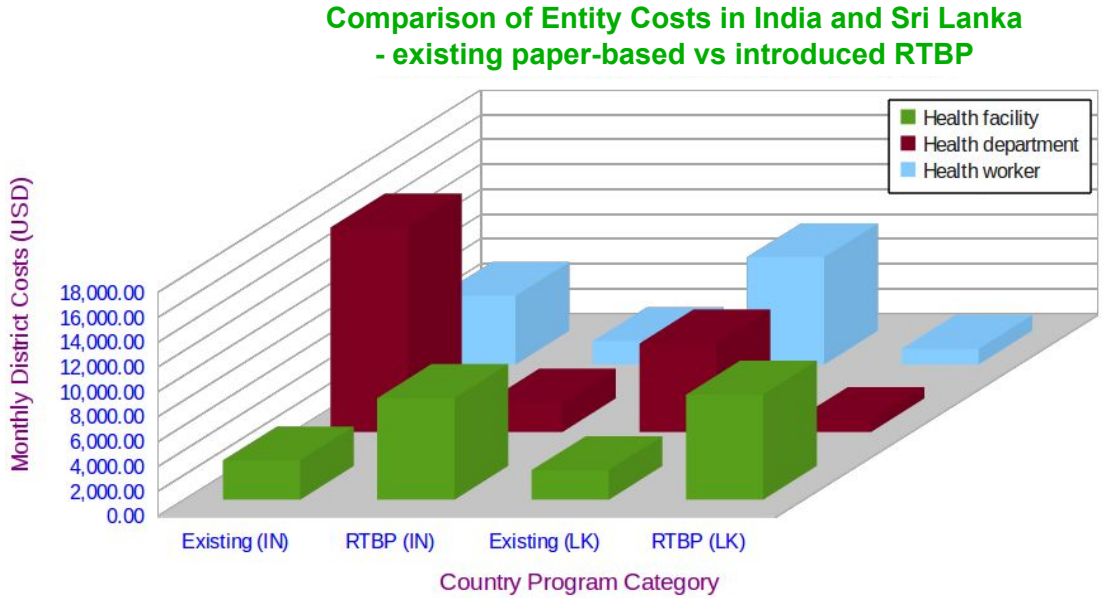


India and Sri Lanka invest very little or no resources on real-time event detection and alerting, ~ **88% in data collections**

RTBP **can reduce TCO > 35%**, moreover, increase timeliness, and introduce rapid detection and alerting

Existing trend analysis is for long term planning only; **dual data-entry at departments**.

Comparison of expenses in relation to the health facility, health department, and health workers



Digitizing data at the point of care removes the bulk health department expenses of labor intensive data aggregation and consolidation.

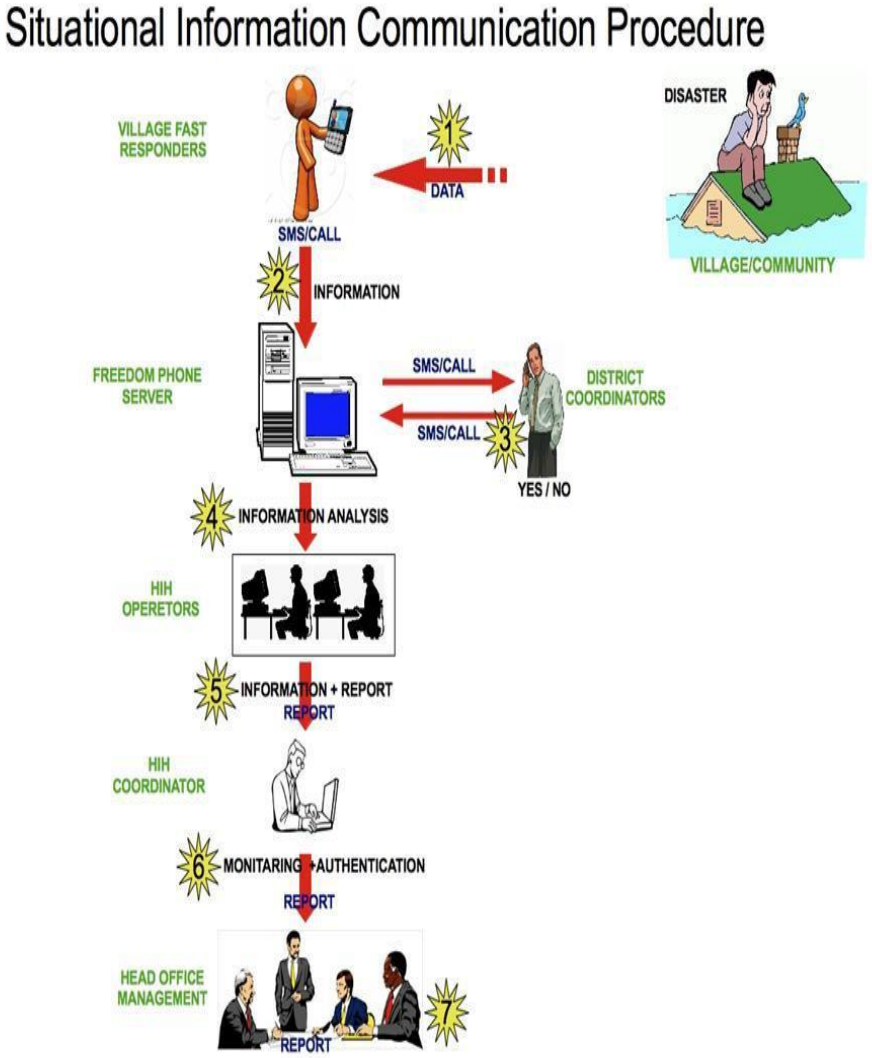
Worst case scenario of bundling frontline data digitizing with new resource person increases the health facility investment.

Health facility cost increase < health department money saved**; India: 61% < 86%, Sri Lanka: 72% < 87%**

[Existing (IN) = present system in India (Integrated Disease Surveillance Program); Existing (LK) = present system in Sri Lanka (Disease Surveillance and Notification Program); RTBP (IN), RTBP (LK) = Real-Time Biosurveillance Program in India and Sri Lanka, respectively]

Voice-enabled ICTs in Emergency Communication

Two key consecutive operations for community-based emergency response



ALERTING

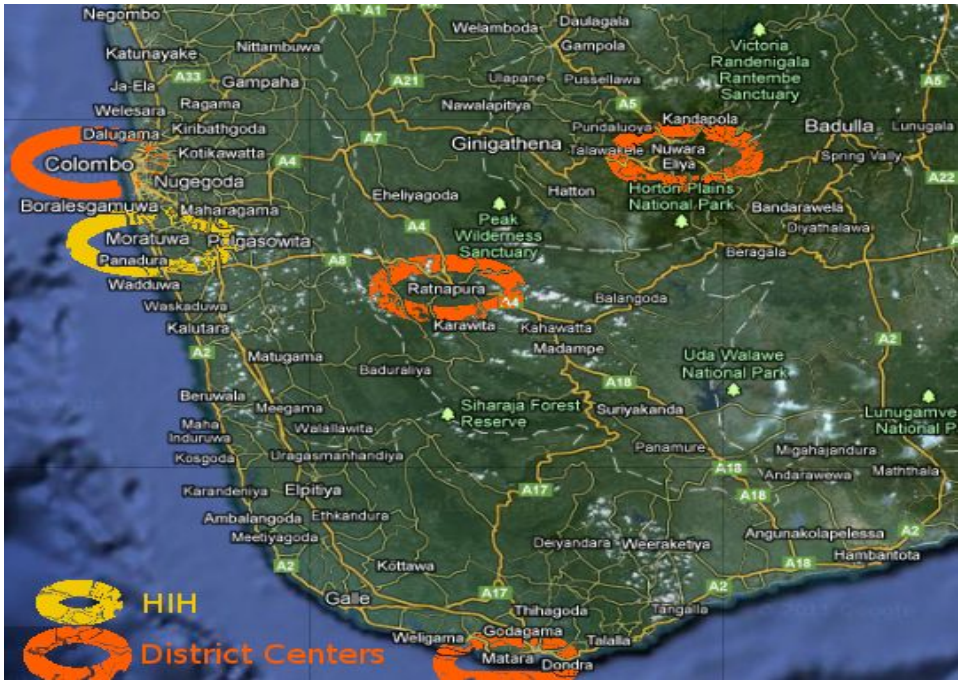
Following a hazard event activate CERT members and HIH operators to identify the incidents, then report the field observation

REPORTING

Receive field observation reports, process them at the Hazard Information Hub to create Situational Reports

Research Design

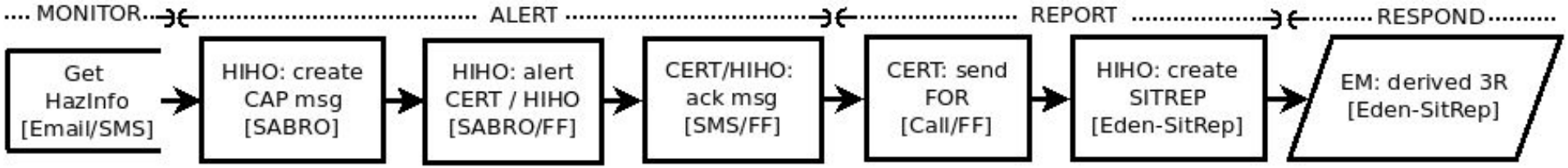
- Principal: Lanka Jathika **Sarvodaya** Shramadana Sangamaya
  - Sri Lanka's largest community development NGO
  - Also provide humanitarian services
- Hazard Information Hub @ Community Disaster Management Center, Moratuwa, HIH Manager, 3 HIH Operators
- Four Districts: Colombo, Matara, Nuwara-eliya, Ratnapura, ~ 10 - 15 CERT members from each district: Divisional/District Coordinators, Staff



Formative Evaluation Method

Controlled Exercises

- Discussed operating procedures (goal, intention, action)
- Executed those procedures (execution, perceiving, interpreting SoW)
- Evaluated the outcomes (Performance, Usability)



Complexity:

- Interaction techniques (HCI)
- Reliability - mean time to completion & voice quality (ITU-T)

Usability:

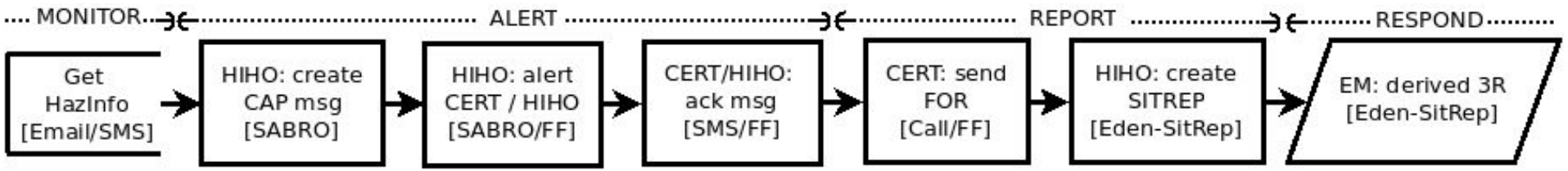
- Human action cycle (HCI)
- Gulf of execution/evaluation (HCI - what system allows and understanding of SoW)

Utility:

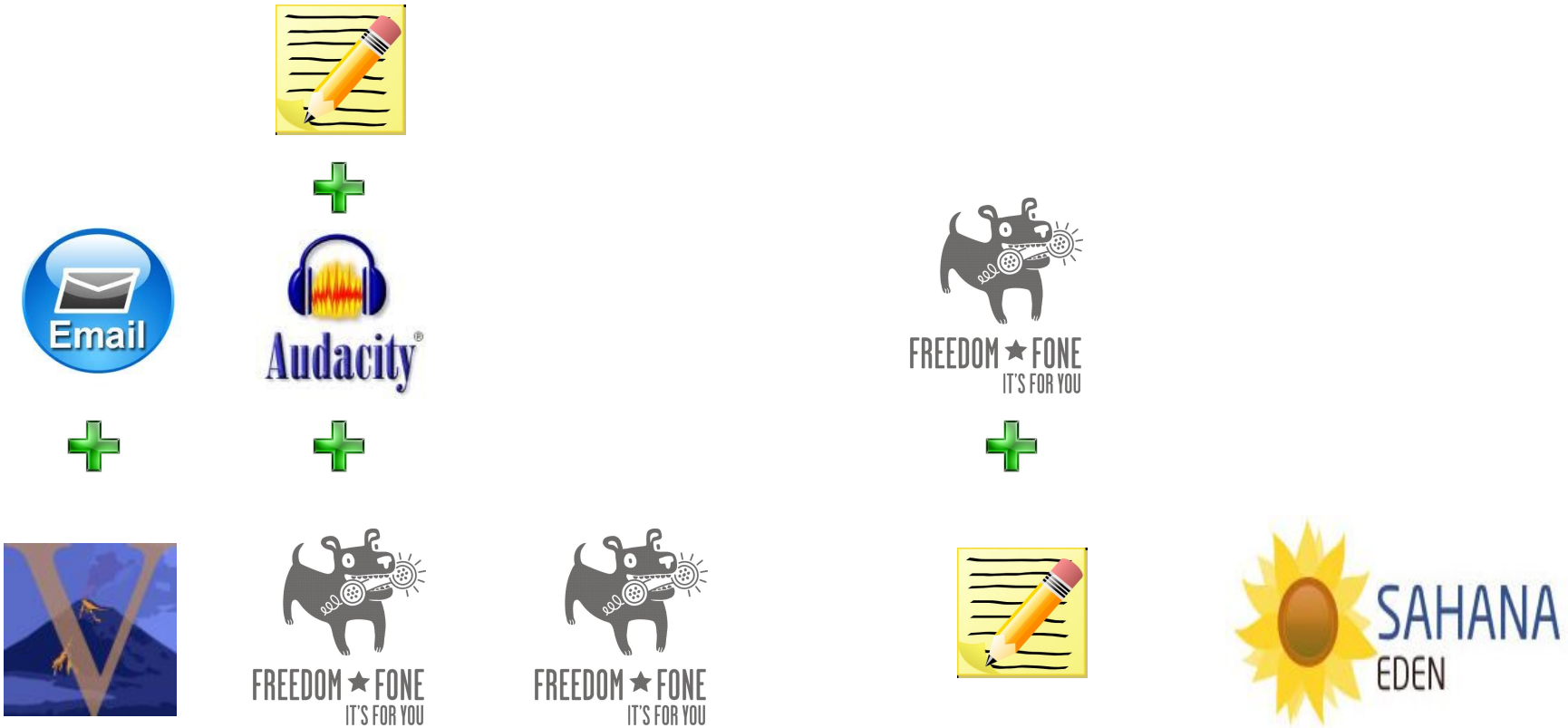
- Ease-of-Use, Usefulness, and Attitude (TAM)

Mean Time to Completion

Actions:

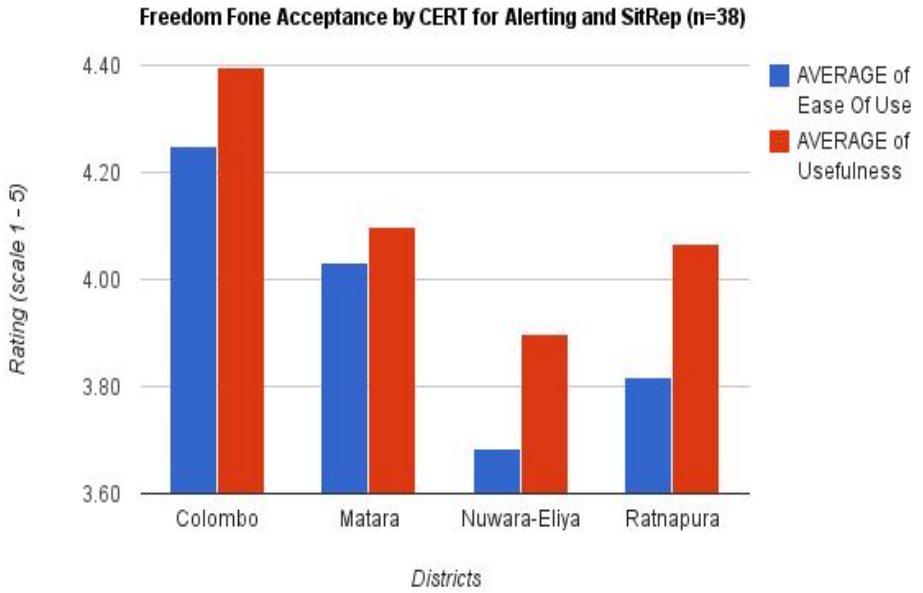


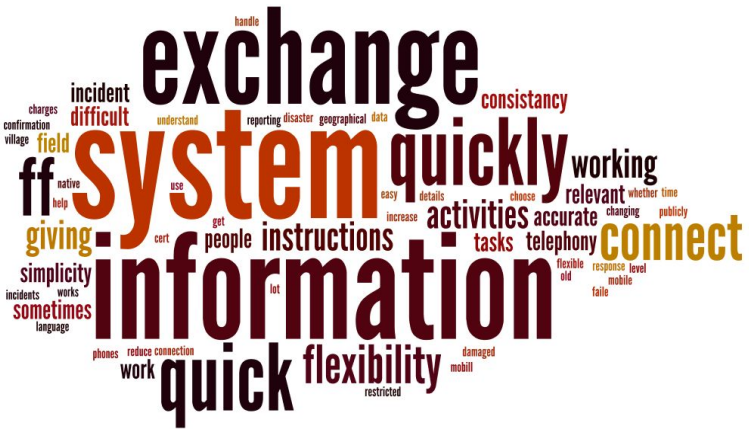
Applications:



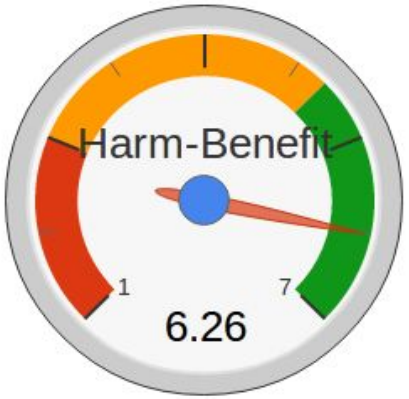
Process	SABRO CAP Alerting	FF Voice Alerting	FF Acknowledgement	FF Field-Observation report translation	Eden-SitRep create record
Time (mm:ss)	19:25	09:06	12:21	08:57	23:38

CERT perception of alerting and reporting



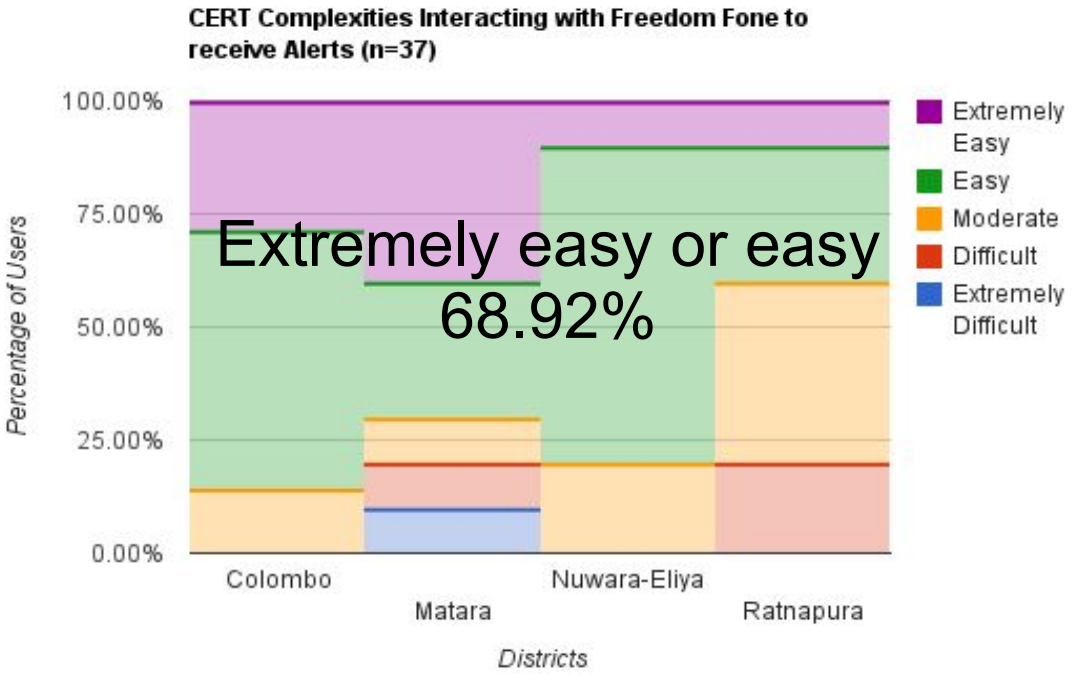


"All things considered, Freedom Fone, for alerting and reporting is a(n) _____ idea"

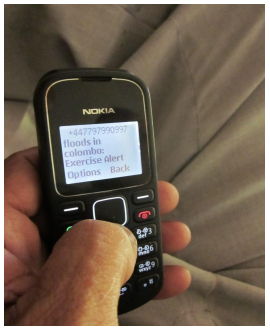


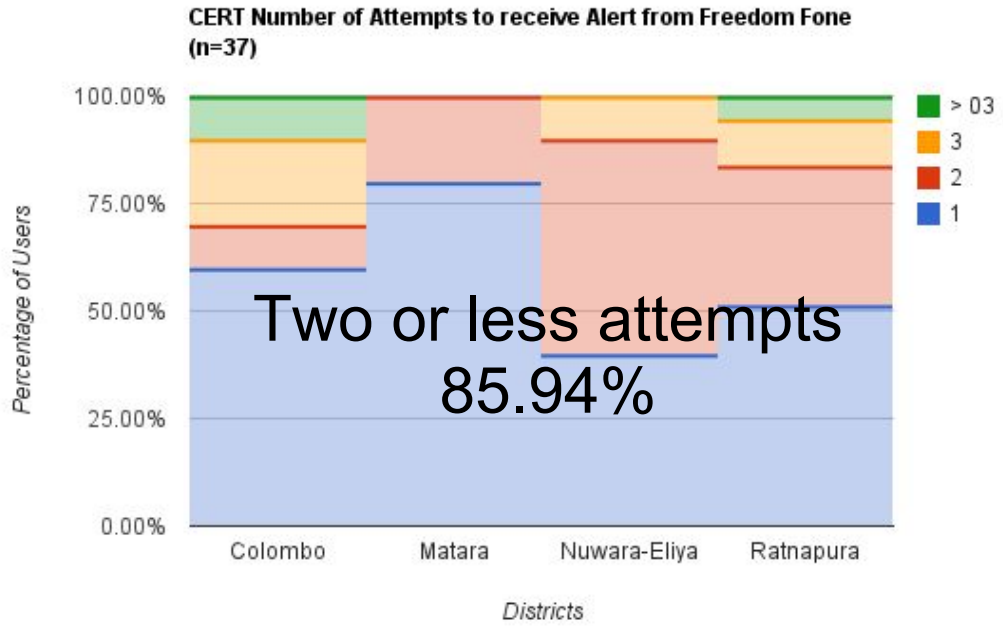
"Present Sarvodaya methods are ad-hoc and informal unaccountable, but Freedom Fone stores a record of the story ... no one can say otherwise."

CERT members receiving ALERTS through Freedom Fone



Avg. Call Time: 2:13 min
Avg. Msg Time: 1.59 min

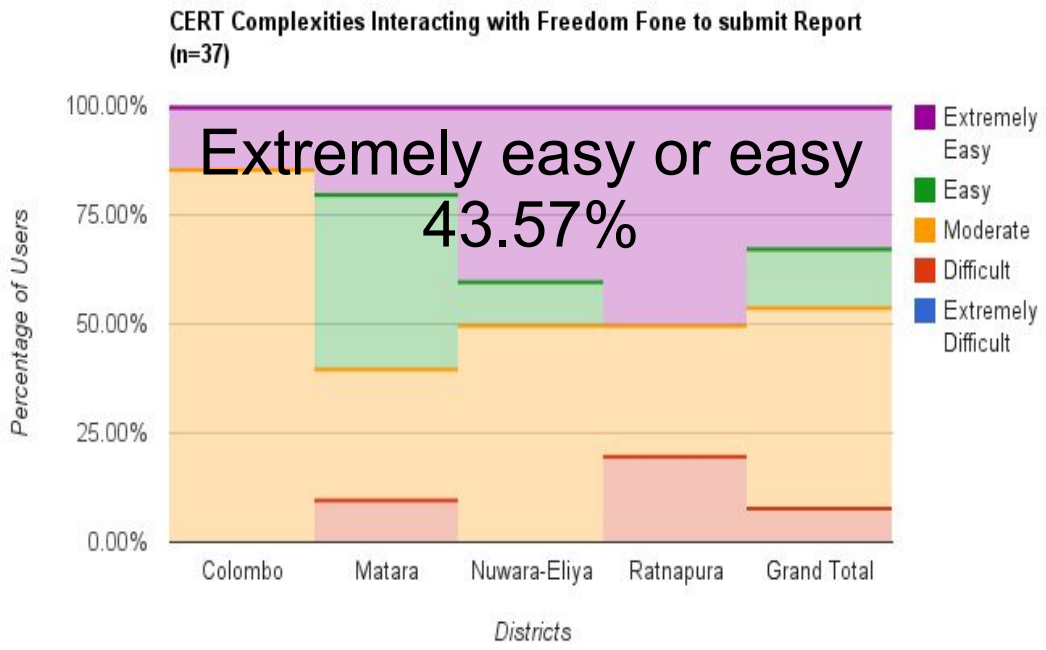




<u>Menu selection sequence:</u>

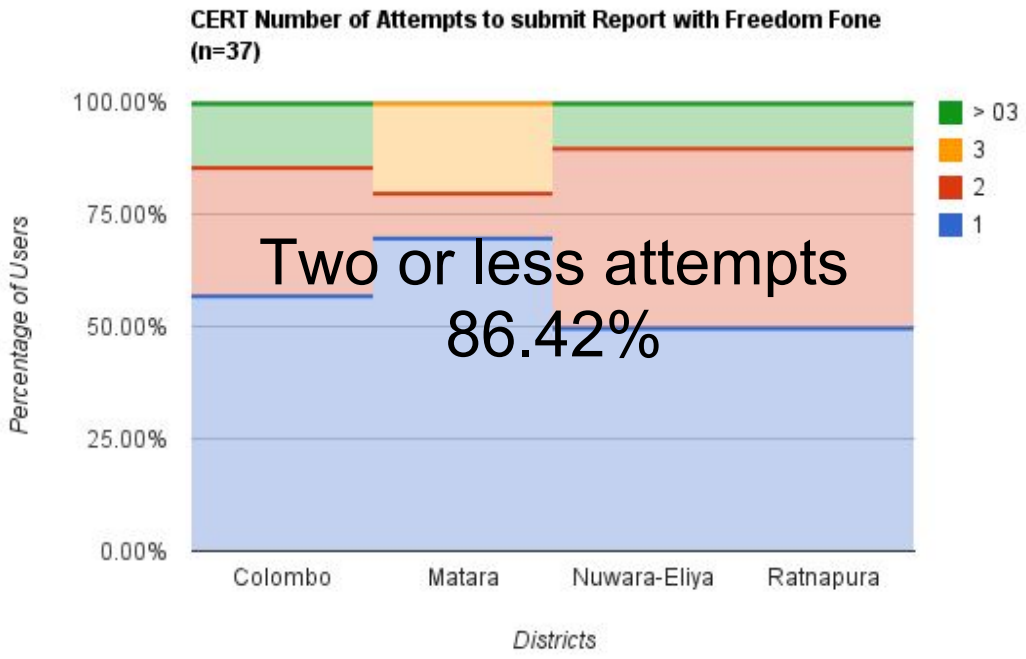
1. Language (press #1 for sinhala)
2. Listen to Alerts (press #1 for Alerts)
3. Select to Alert (press #2 for "landslide in Ratnapura 2011 Nov 10)

CERT members REPORTING Field Observations through Freedom Fone



Avg. Call Time: 2:33 min

Avg. Msg Time: 1.38 min



<u>Menu selection sequence:</u>

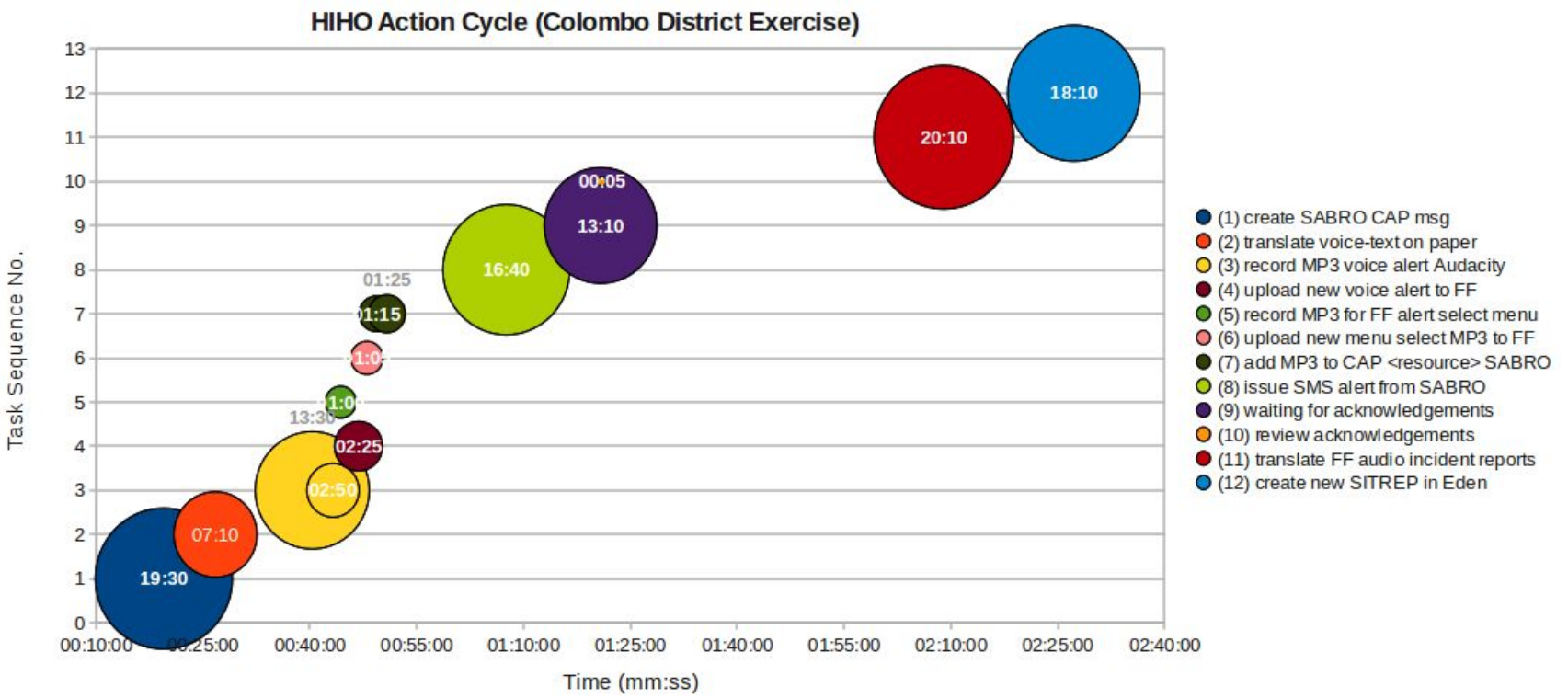
1. Language (press #1 for sinhala)

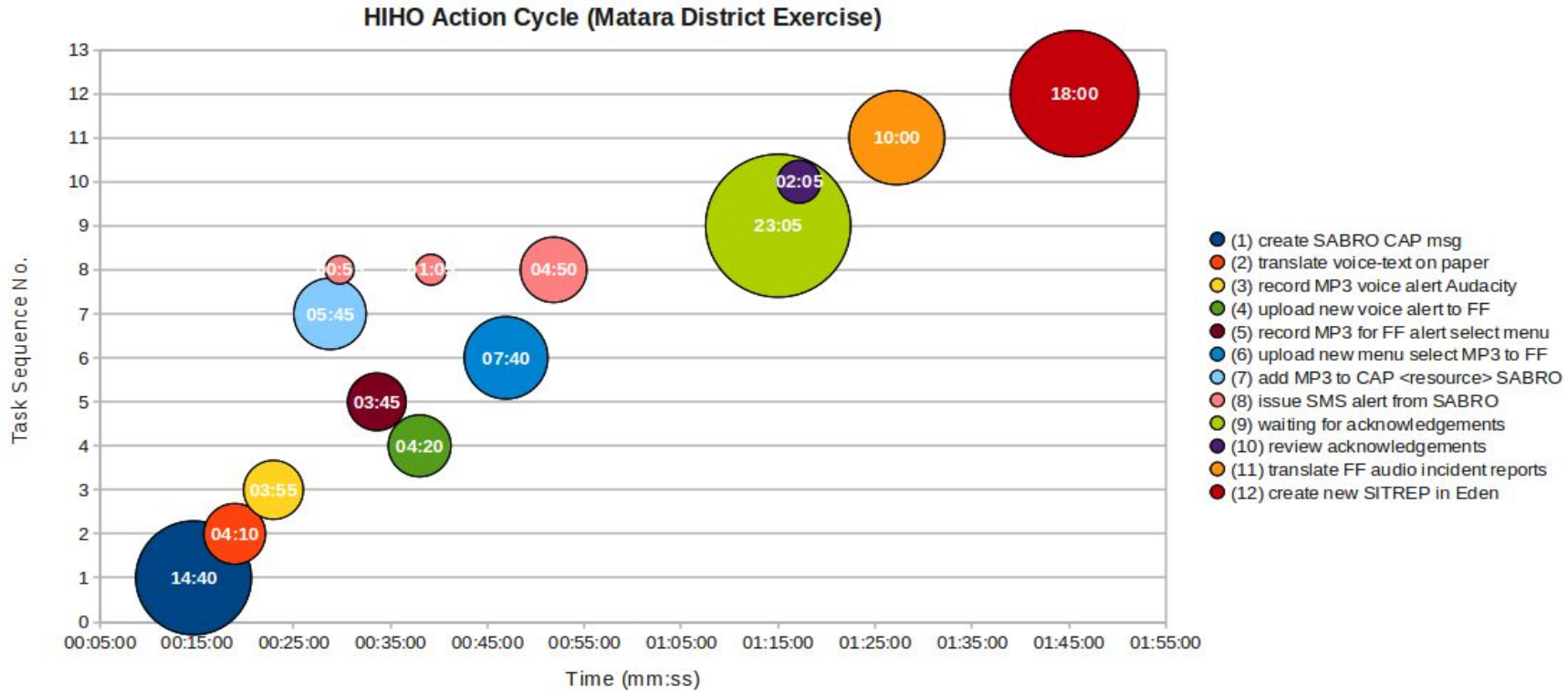
2. Submit a Report (press #2 for reporting)

3. Begin recording after the beep

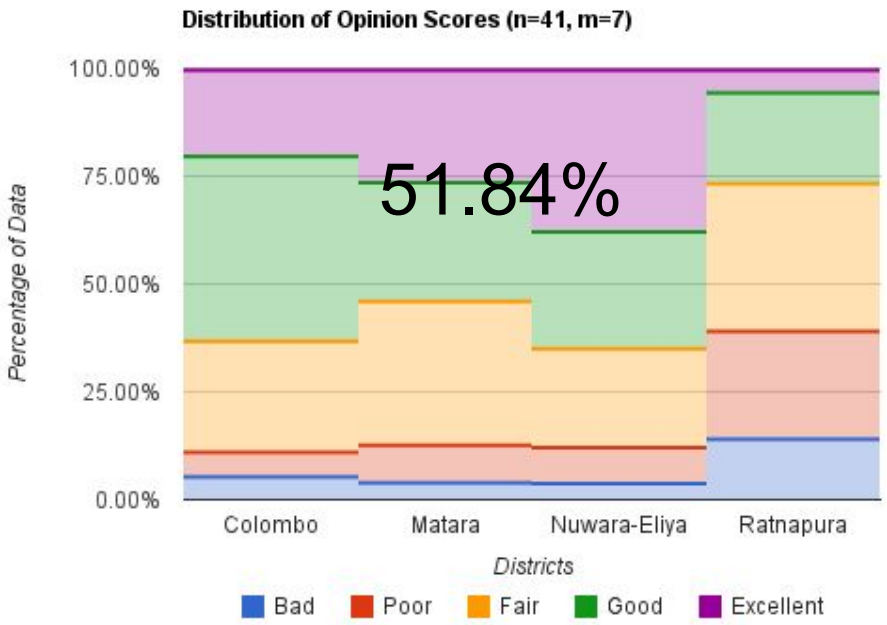
3. Save report (press # to save, press #1 to listen, press * to delete)

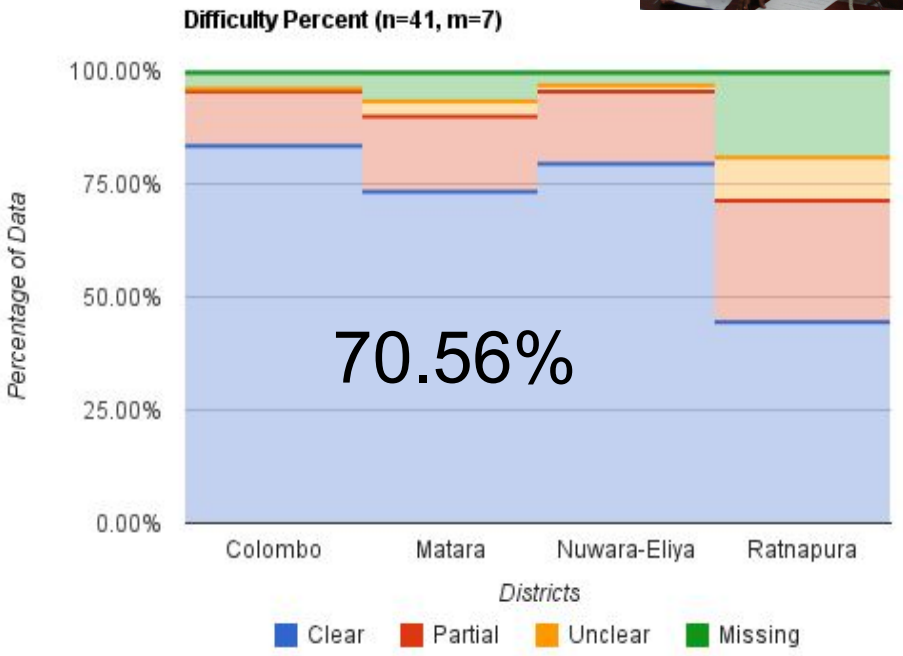
Task sequence (Y-axis), time-series (X-axis), and duration (blurb volume)

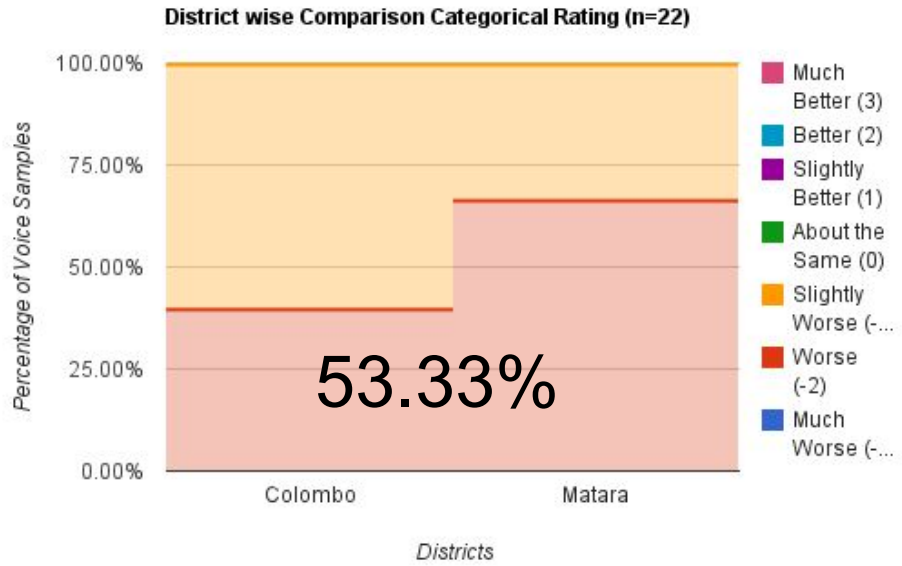




Summary of ITU P.800 results







- Circuit (or mechanical) noise degrades MOS ~ 50% bad, poor, and fair
- Partial, Unclear, or Missing information can lead to false predictions/actions and inefficiencies, ~30% of info was difficult to decipher
- All telephone samples at data center worse than on-site digital recording

How to calculate the 2 x 2 contingency table

Filter the evaluators', five key, difficulty score responses to the data elements

District	3 Report Purpose	5 Observation Location	7 Observation text	8 Action Plan	9 Immediate Needs	What is the overall MOS?
Colombo	Partial	Clear	Clear	Clear	Clear	4
Colombo	Clear	Clear	Clear	Clear	Clear	4
Matara	Partial	Unclear	Unclear	Partial	Partial	3
Matara	Clear	Partial	Clear	Partial	Clear	3

Cut-Point=1

District	3 Report Purpose			
	TP	FP	FN	TN
Colombo	0	1	0	0
Colombo	1	0	0	0

Calculate the TP, FP, FN, & TN for each Cut-point 1, 2, 3, 4, 5

Aggregate the TP, FP, FN, and TN for each cut-point and district; calculate Sensitivity and Specificity

	TP	FP	FN	TN	Sensitivity = TP/(TP+FN)	Specificity = TN/(TN+FP)
Cutto01						
CO	140	25	7	3	.9524	.1071
MH	252	78	0	15	1.0000	.1613
NE	192	38	0	10	1.0000	.2083
RN	179	146	4	51	.9781	.2589

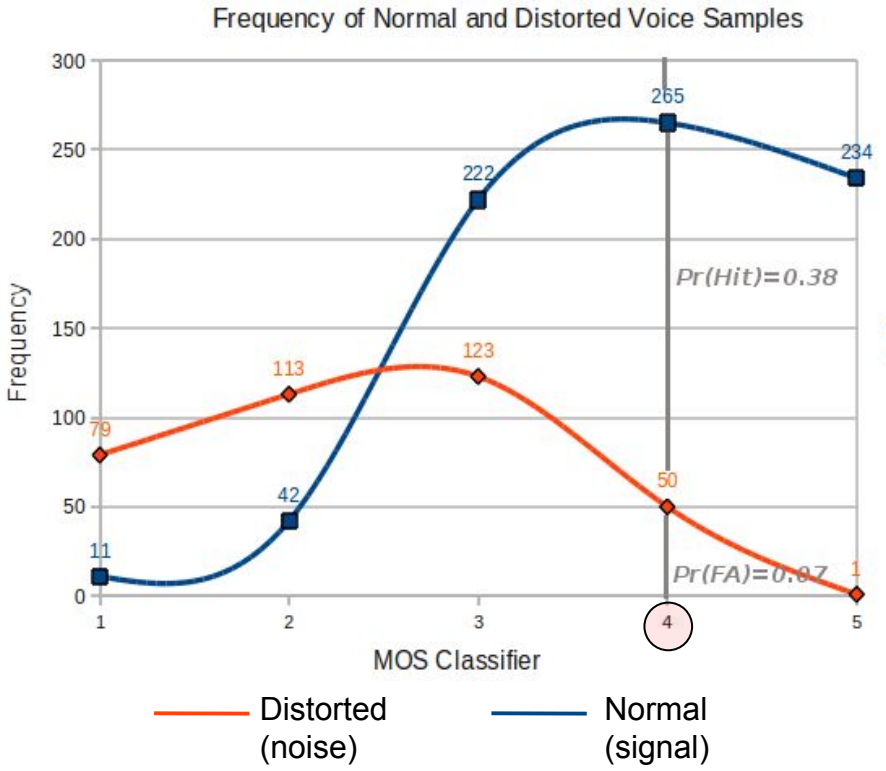
Justifying the Cut-Point

CERT members (subjects) generated voice samples records = 48

Those evaluated by people: m = 7

Clea records available for analysis = 228 of 336

After splitting the record into five data element, samples: n = 1140



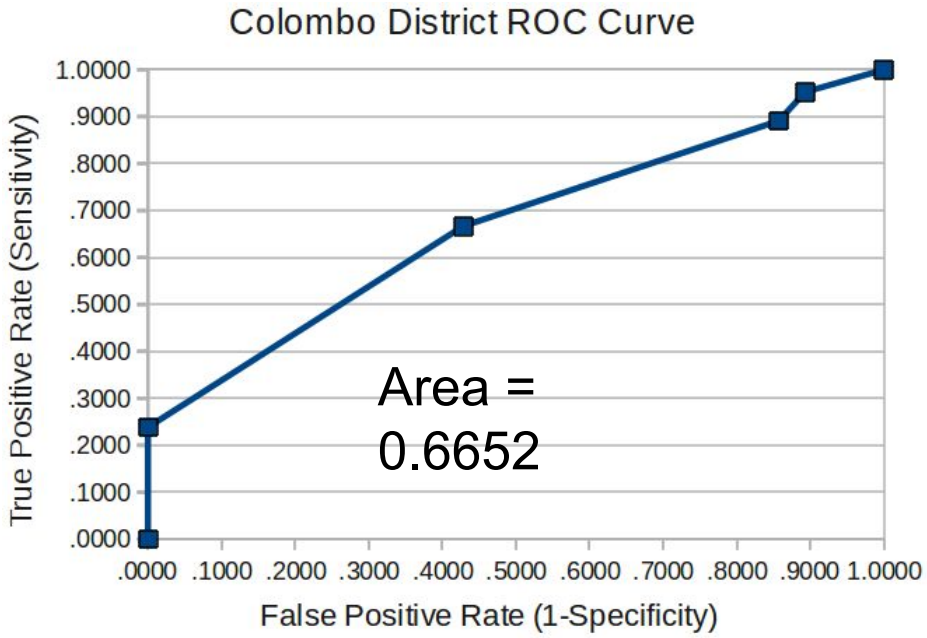
Summary of normal and distorted curve overlapping areas

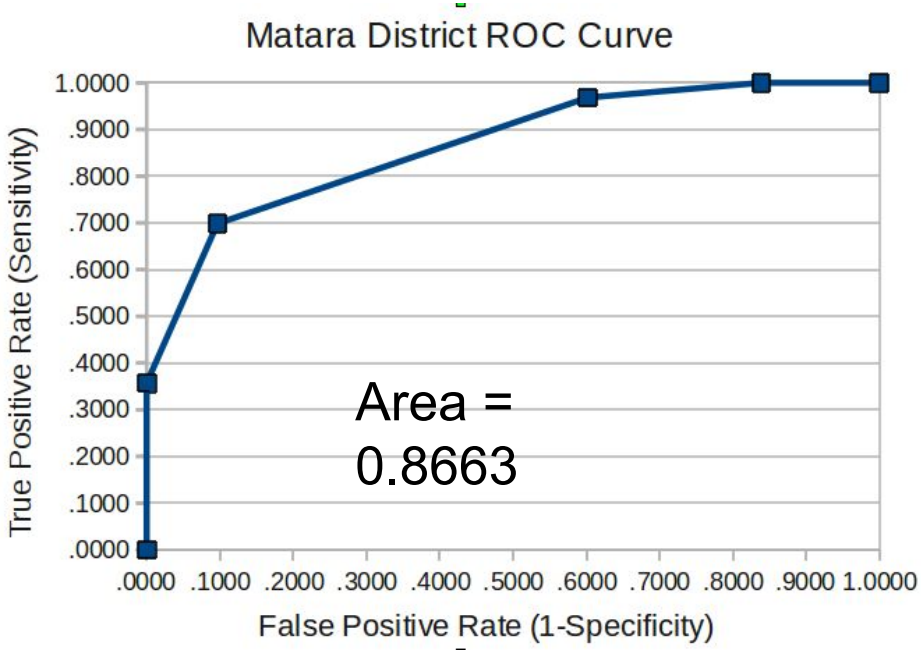
Cut-Point	Area under normal curve	Area under distorted curve	Overlapping area %
1	26.50	96.00	100.00%
2	1132.00	118.00	70.55%
3	243.50	86.50	34.36%
4	249.50	25.50	7.82%
5	0.00	0.00	0.00

FP rate = 7.82% is tolerable, any uncertainties can be reconfirmed

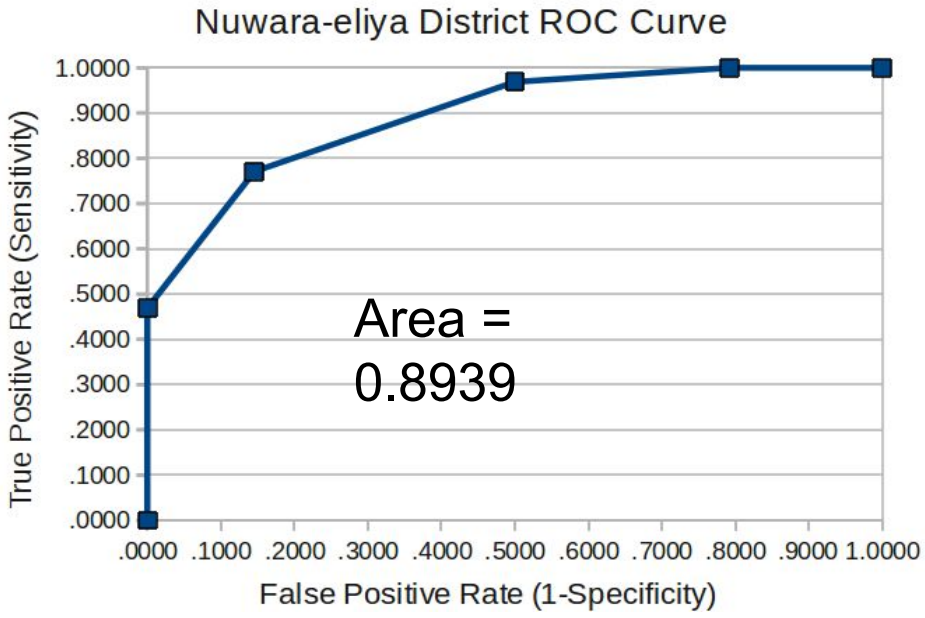
TP rate = 38% not good enough

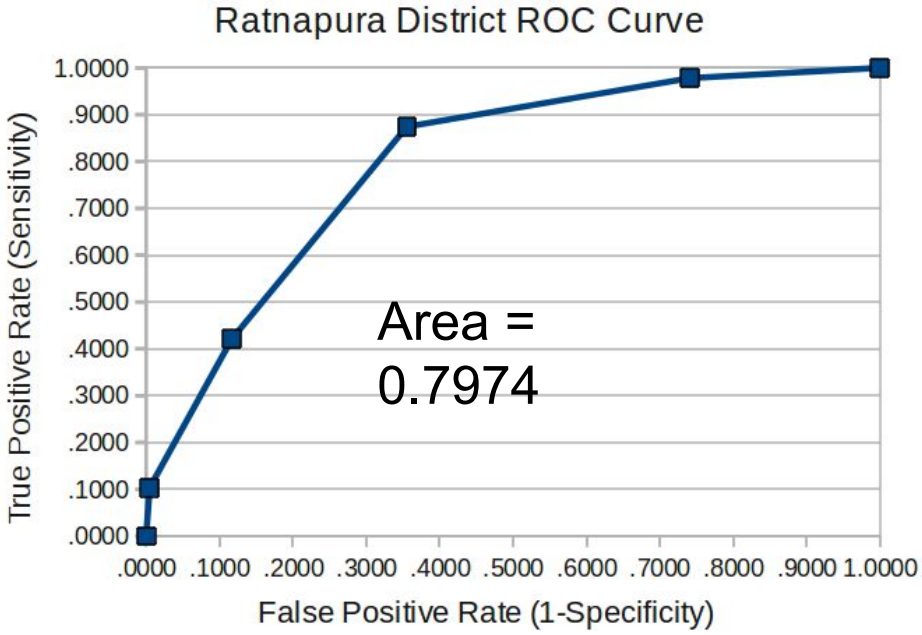
District-wise ROC curves





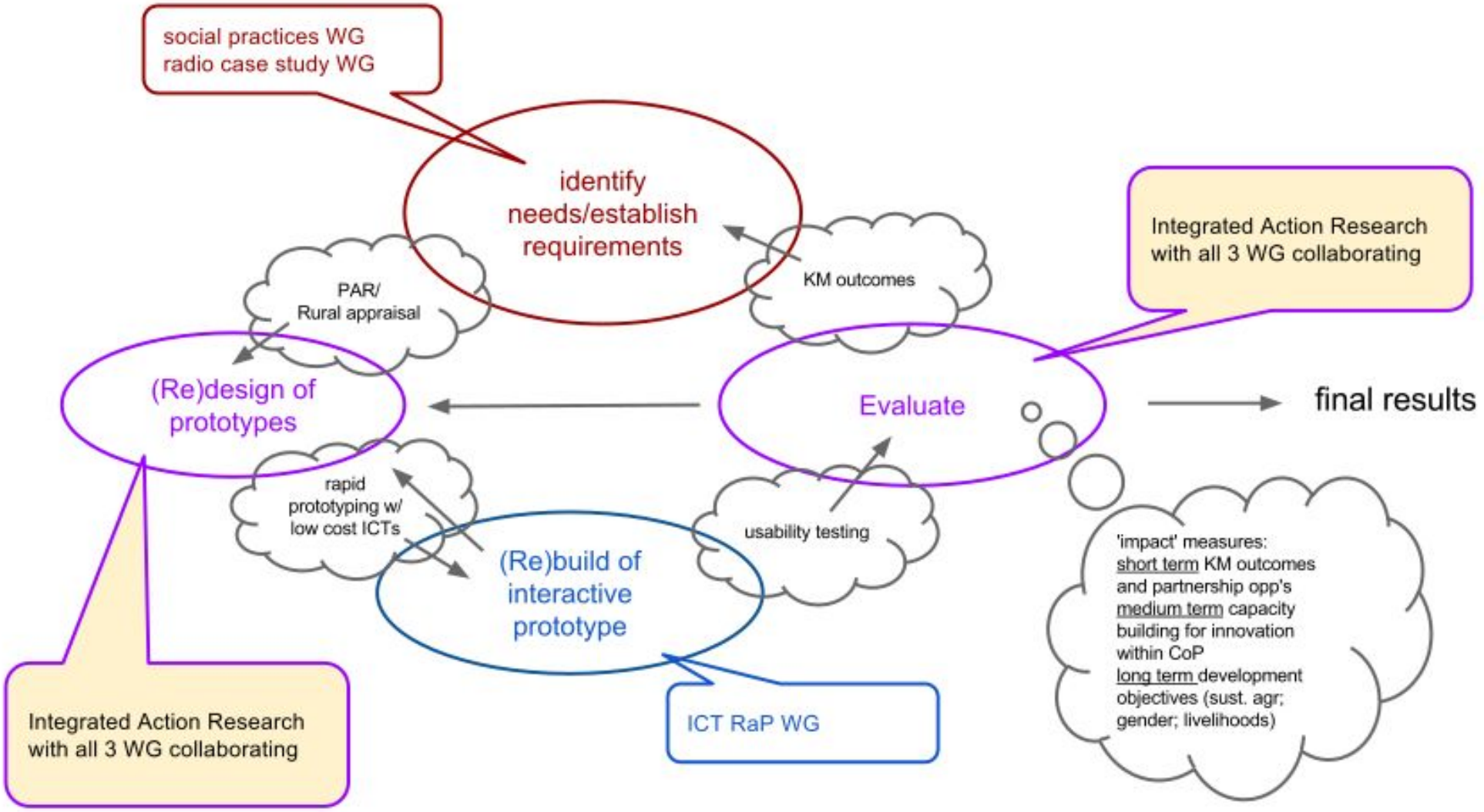
- Except Colombo all others agree ~80% with classifier
- Colombo behavior could be pure chance?





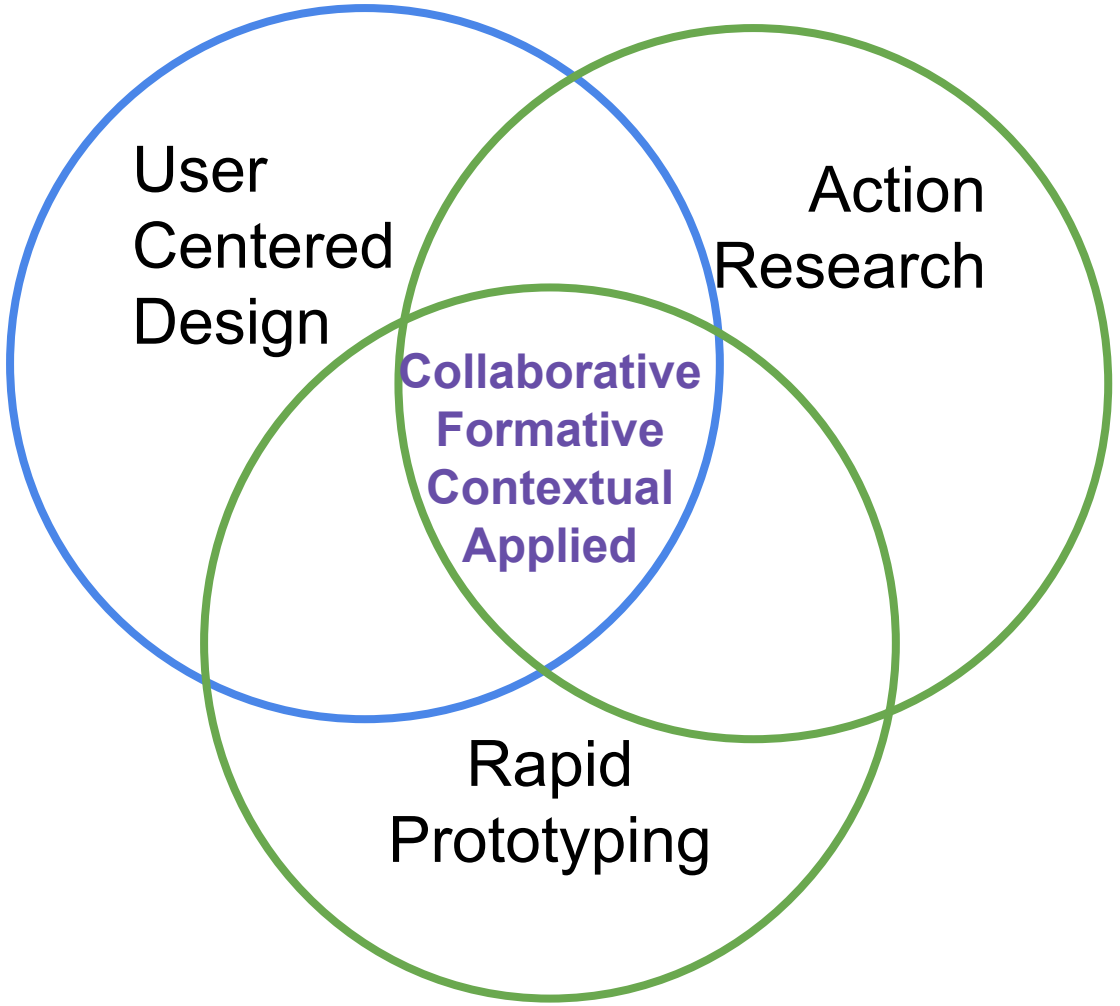
Innovative Use of ICT in Agriculture Knowledge Mobilization

Integrated approach to action research



Interaction design model adapted from Preece, et al., (2007)

Drawing from the literature survey



The three areas share common traits on emphasizing methods, processes, outcomes that are collaborative, formative, contextual, applied

Rapid Prototyping

Sustainability starts with

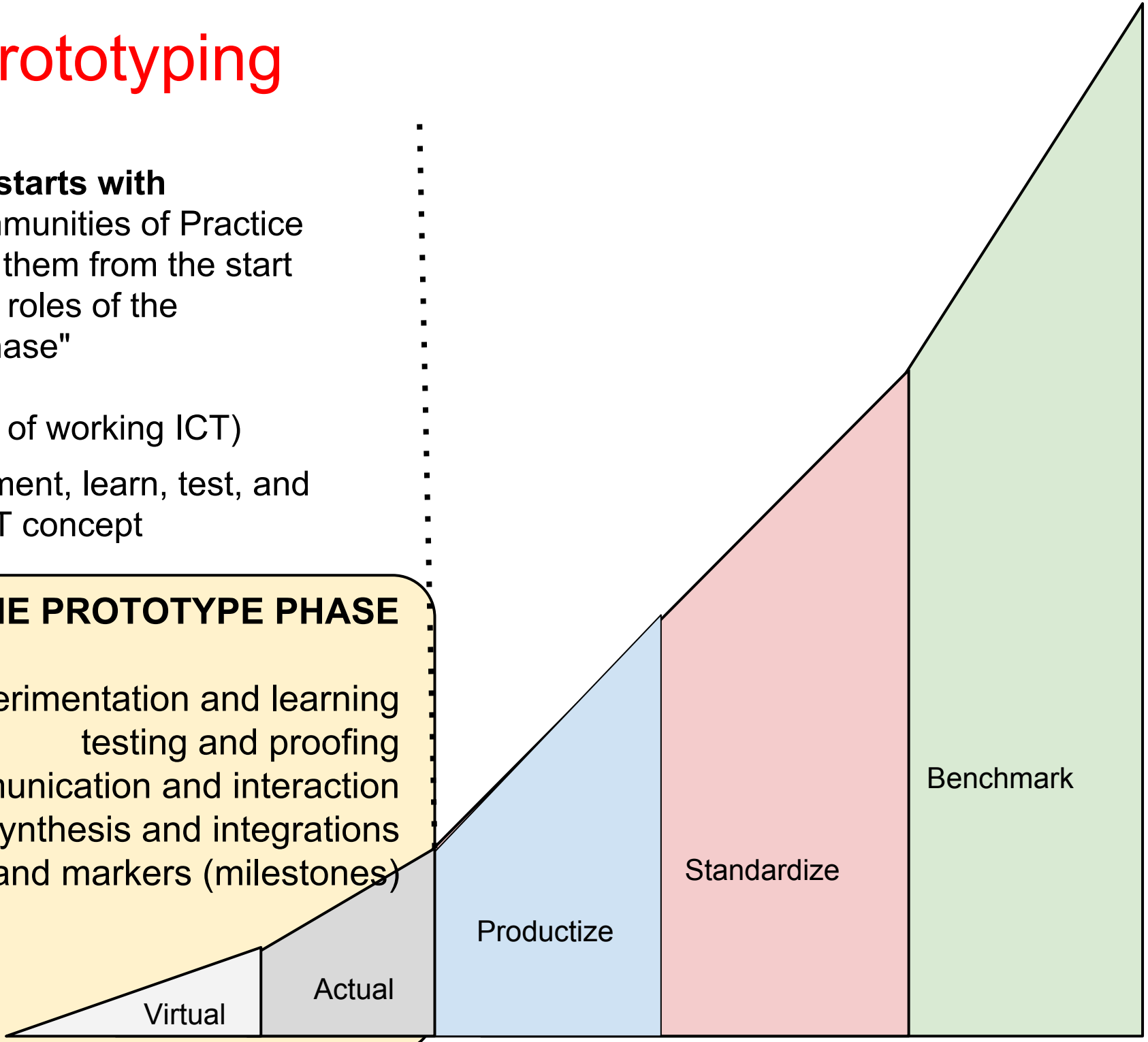
- identify Communities of Practice and engage them from the start through "the roles of the prototype phase"

Concept (proof of working ICT)

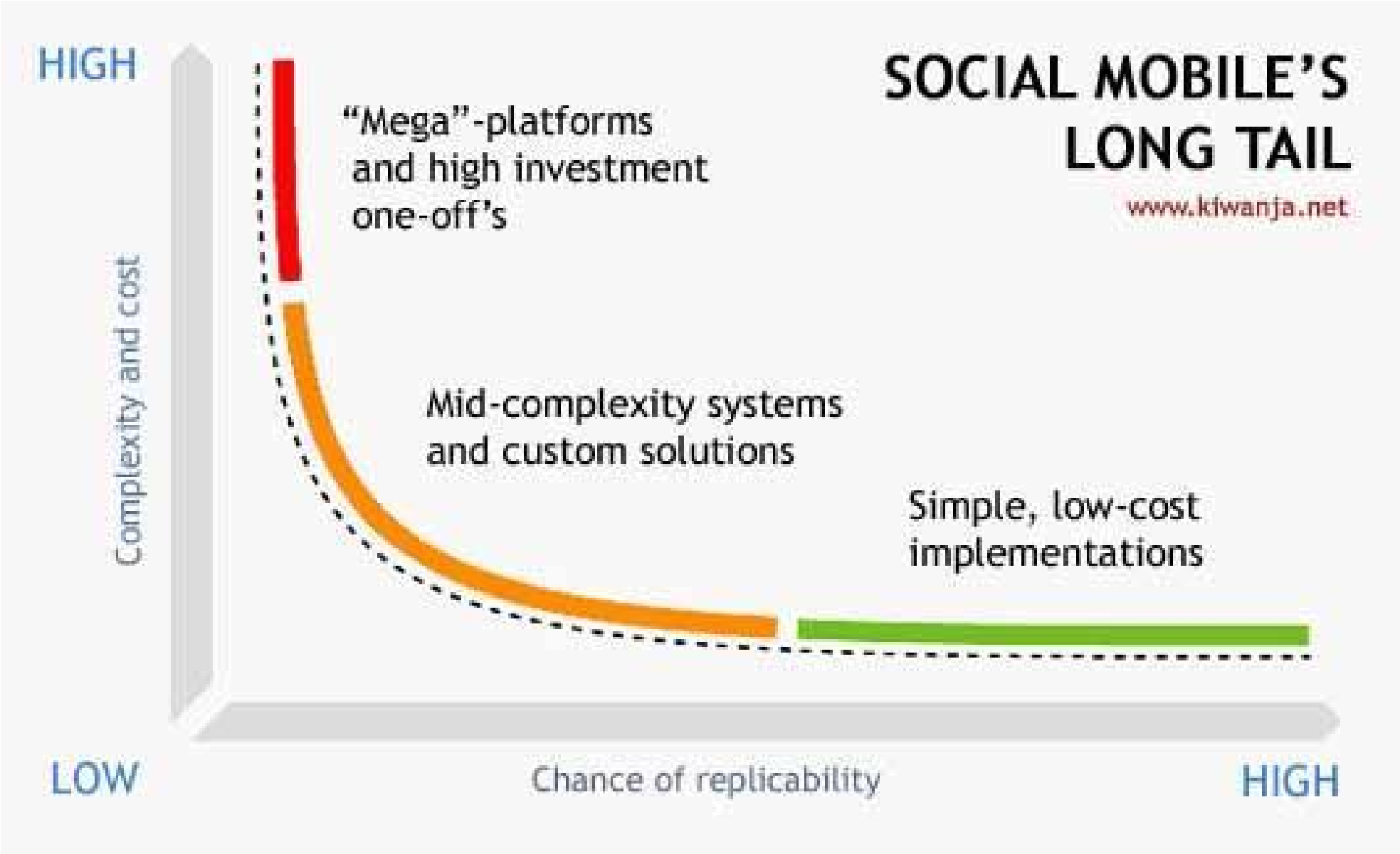
- Let's experiment, learn, test, and proof the ICT concept

ROLES OF THE PROTOTYPE PHASE

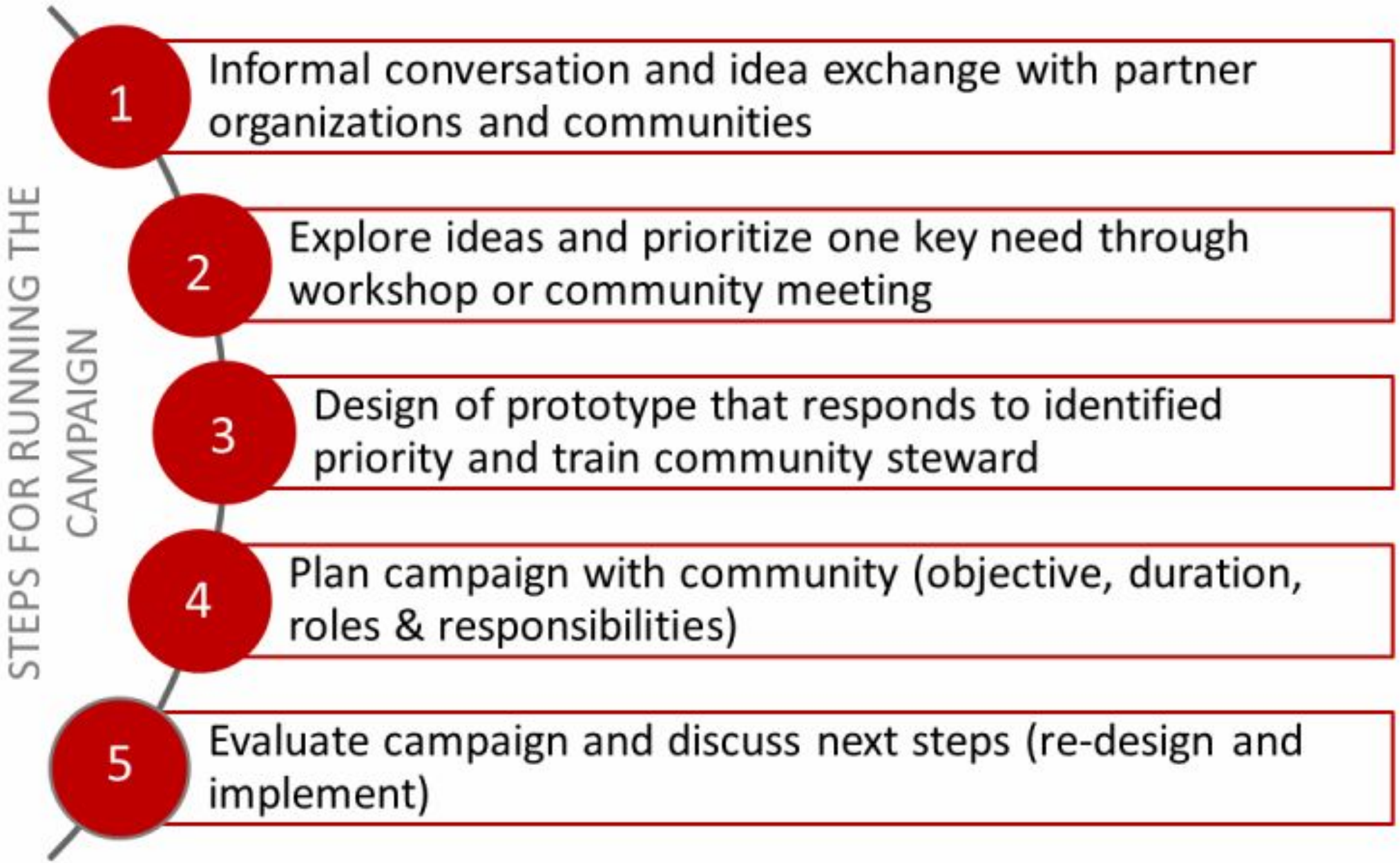
Experimentation and learning
testing and proofing
communication and interaction
synthesis and integrations
scheduling and markers (milestones)



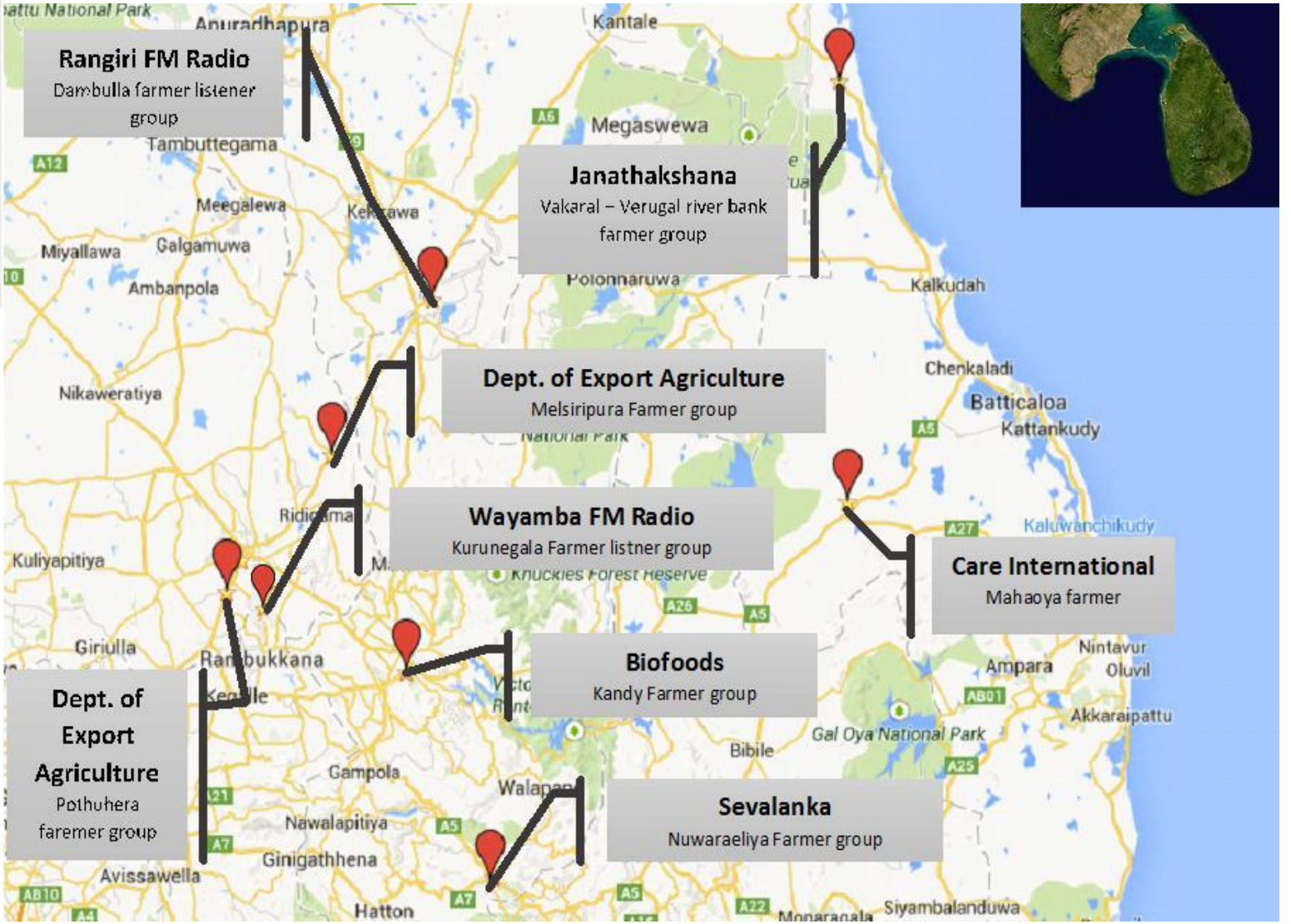
Low-cost ICTs



Creating a Campaign



Prototyping with Multiple Commuities



Janathakshan Campaign

***Campaign Locations**:* Verugal and Kathiraveli Grama Niladhari divisions in Koralai Pattu North Divisional Secretariat and Kirankulam Grama Niladhari division of the Munmunai Pattu Divisional Secretariat in Batticaloa District.

Farming Practices: subsistence farming & fishing.

Vakarai & Kathiraweli - seasonal crops and vegetables in the Verugal river bank

Campaign focus: vegetable cultivation

Campaign objective: communication among farmers, mainly general messaging regarding

1) pricing information and general farming information

2) elephant threats to crops and harvest

3) flash flood warning (occurs 1-2 times every year)

Technology Steward: Mr. Kamalaraj -Technical | UN Habitat -Operational officer

FLSMS keywords: regv, regk, kdrall, krall

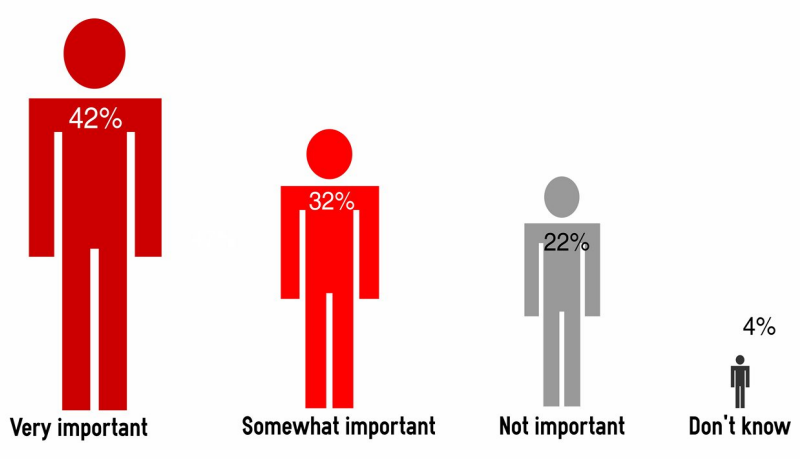
Campaign period: Started on 02nd May 2014 and ended on 09th Sep 2014

Information Seeking

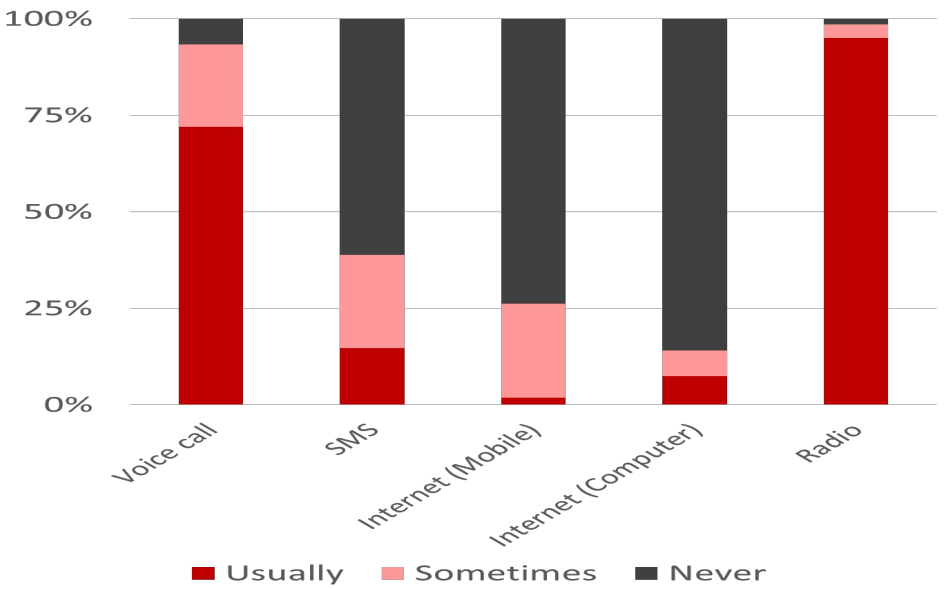
Types of Information

- Market prices of crops
- Crop variety and seed types
- Sustainable, ecological or organic farming practices
- Crop diseases & solutions
- Fertilizers
- Pesticides & herbicides
- Government schemes
- Finances
- Labor availability & costs
- Land availability & costs
- Farming machinery, equipment & costs
- Transportation
- Modes of getting info: voice preferred over SMS
- Packing materials
- Warehouses & cold storage
- Buyers/ collectors/ traders
- Electricity timings
- Water availability
- Weather

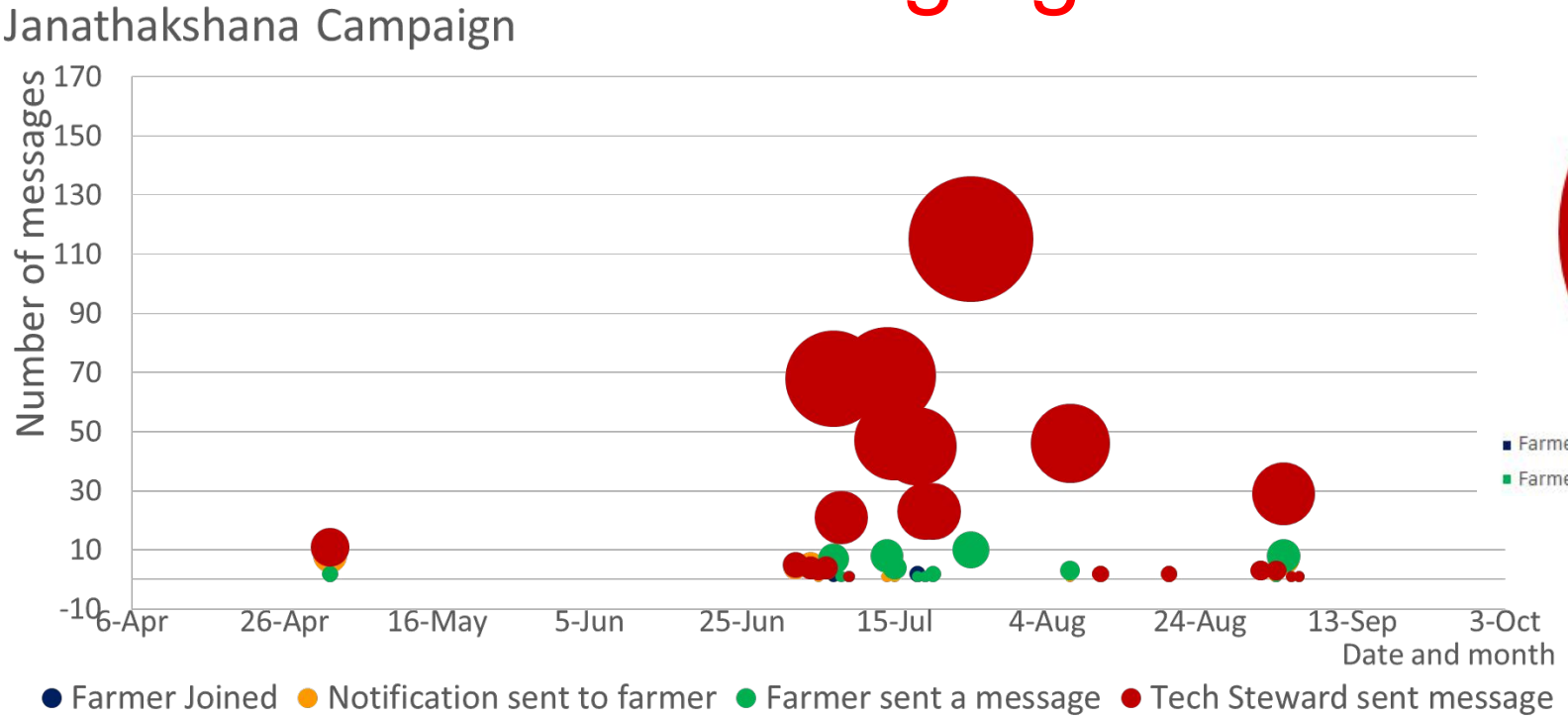
They all want categorical information, "it is important!"

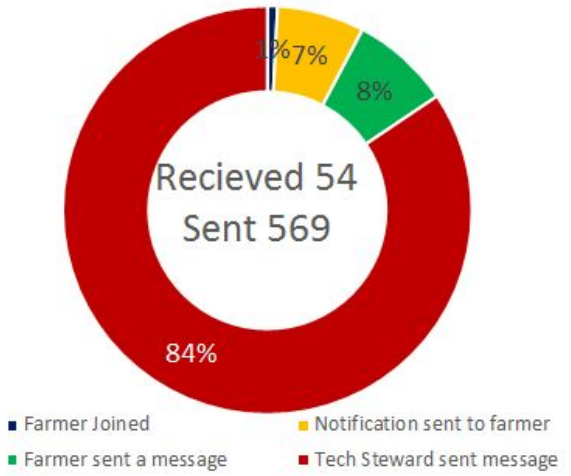


Usually information shared through "phone calls" and "radio".

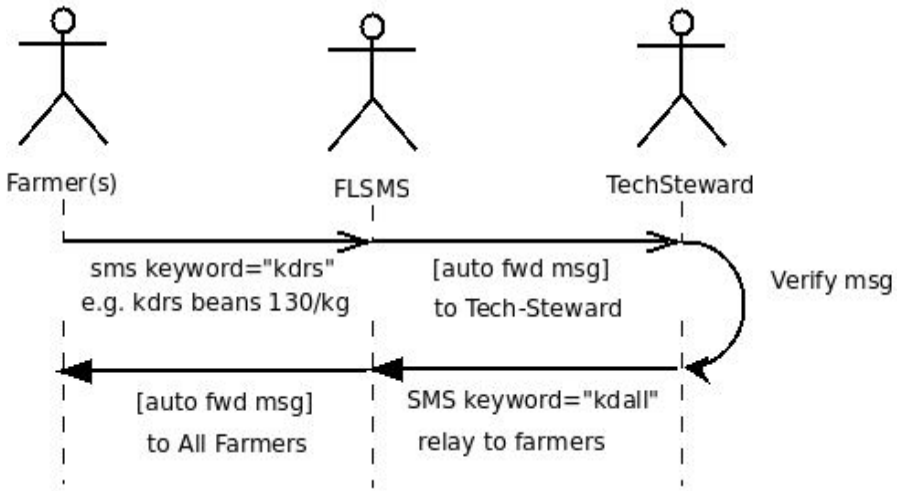


Janathakshan Messaging Practices

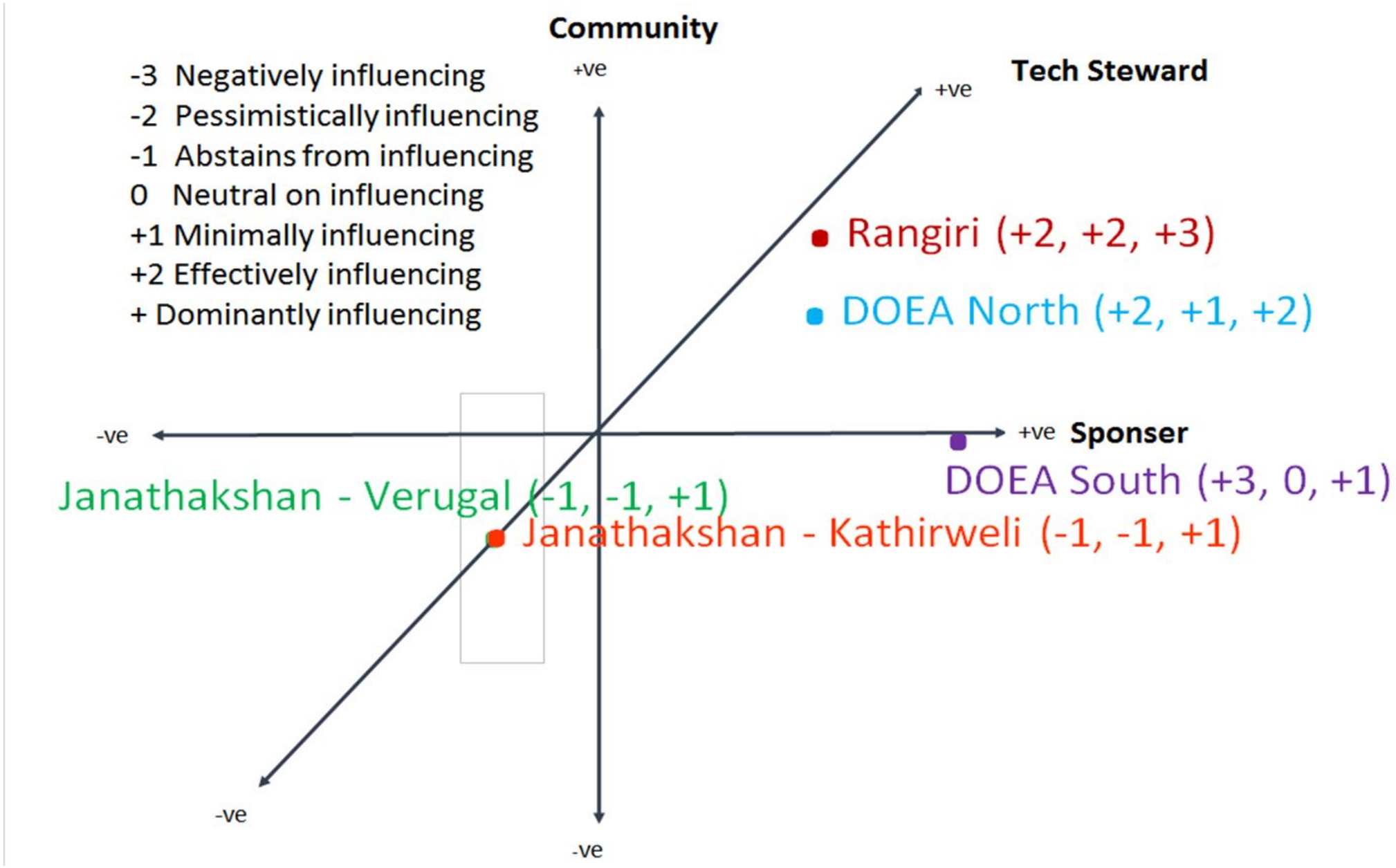




- Orange and Green combination of receive, verify, and relay (security reasons)
- Additional test sequence to ping the machine
- Getting military to provide flash flood warnings didn't materialize (personnel change too often to manage such a program; i.e. military not integrated in to community)
- No elephant attack reports (secondary activity)



Actor Influence Metric (AIM)



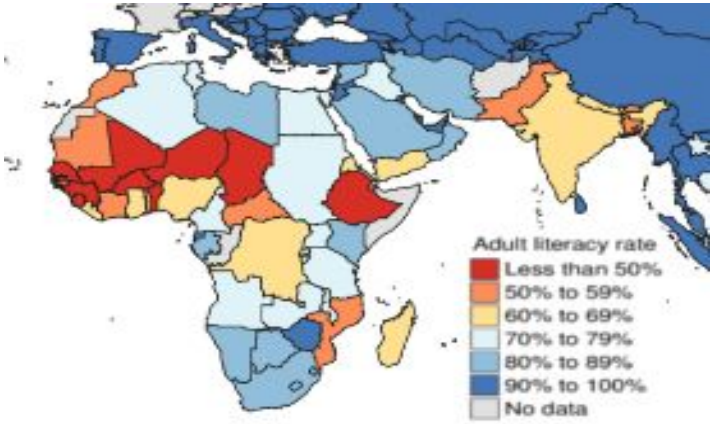
Interpreting AIM Results

DOEA -North	Continue	Technology Steward took keen interesting in promoting the campaign and effectively using the technology; Community saw value in technology and Sponsor was very supportive
DOEA -South	Re-assess and re-design	Technology Steward was relocated distancing from the computer to interact and monitor the technology; thus neglecting the campaign in spite of Community and Sponsor enthusiasm
Janathakshan -Verugal	Re-assess and re-design	Little or no support from Sponsor. Community education level and Latin-script technology a barrier. Technology Steward was detached from Community
Janathakshan -Kathirweli	Re-assess and re-design	Little or no support from Sponsor. Community education level and Latin-script technology a barrier. Technology Steward was detached from Community
Rangiri	Continue	Highly effective Sponsor and Technology Stewards with an enthusiastically participating Community

Classification of Early Warning Systems

Future Projects

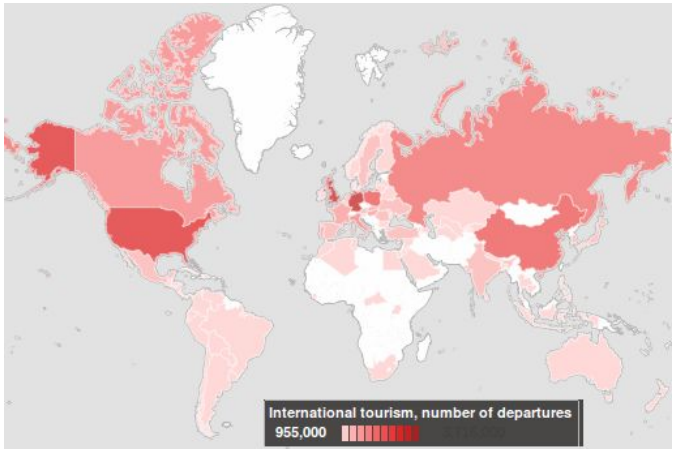
Why Pictographs in Alerting?



~30% avg in South/West Asia and Sub-Saharan Africa are illiterate

~ 10% avg improvement in the last 20 years

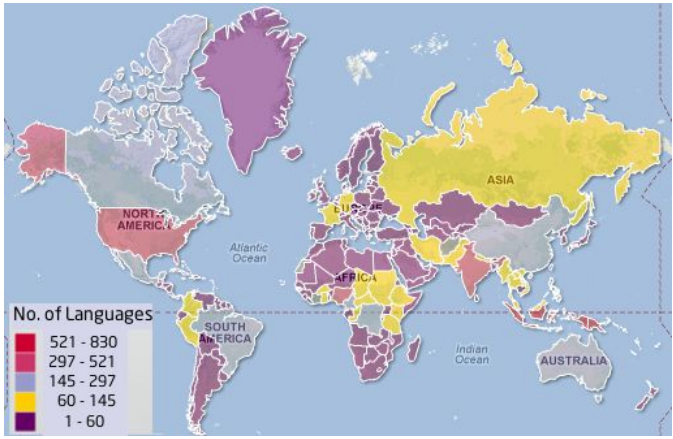
Source UNESCO: http://tinyurl.com/bwj3stl



~ 955,000 million/year international tourism departures 2008-2012

~ 1.6 billion/year foretasted for 2020

Source World Bank: http://tinyurl.com/bwj3stl



Most countries speak more than one language

Many of them with over 50 languages

Source Ethnologue world languages: http://tinyurl.com/csfg45v

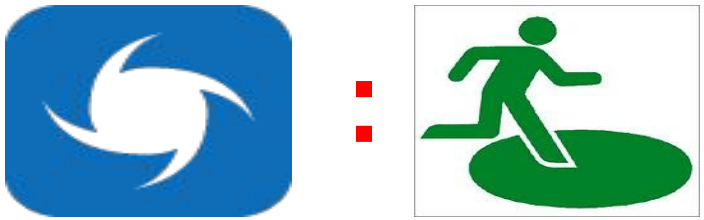
Can we adopt these RESPONSE-Centric Pictographs?

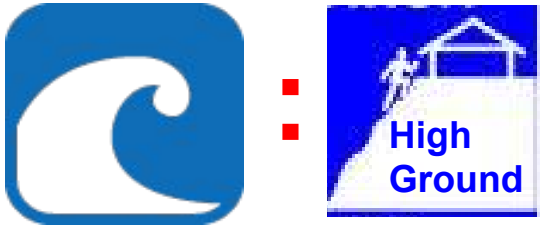
Option A: hazard + response NO ARROW

Hard finding a repository of response symbols

Option B: hazard + response WITH ARROW

Option C: split hazard and response (i.e. display hazard first then the response (flip-flop)



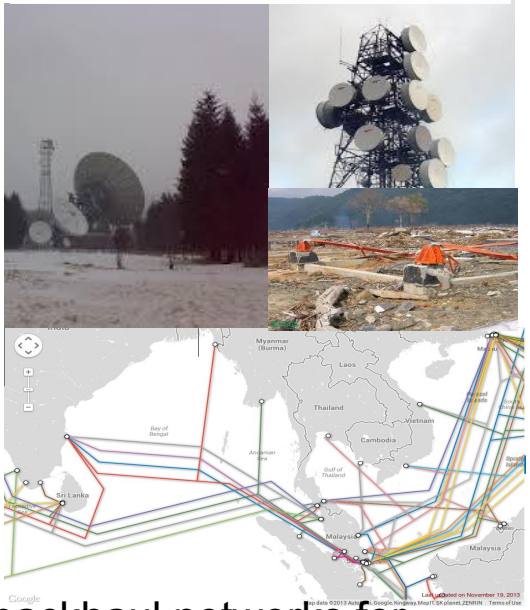


Disaster Response Symbols version 1.0 (beta:) 2009: http://drms.rpec-cert.info/

NO – not exactly the response symbols we need, it's mostly situational awareness and alerting

Resilience of ICT infrastructure

Infrastructure	Vulnerable to
Submarine cables	Earthquakes
Fibre optics	Earthquakes, infrastructure
Microwave	Cyclones, Wildfire, power
HF/VHF	Sever weather
Satellite	Solar flairs, space debris

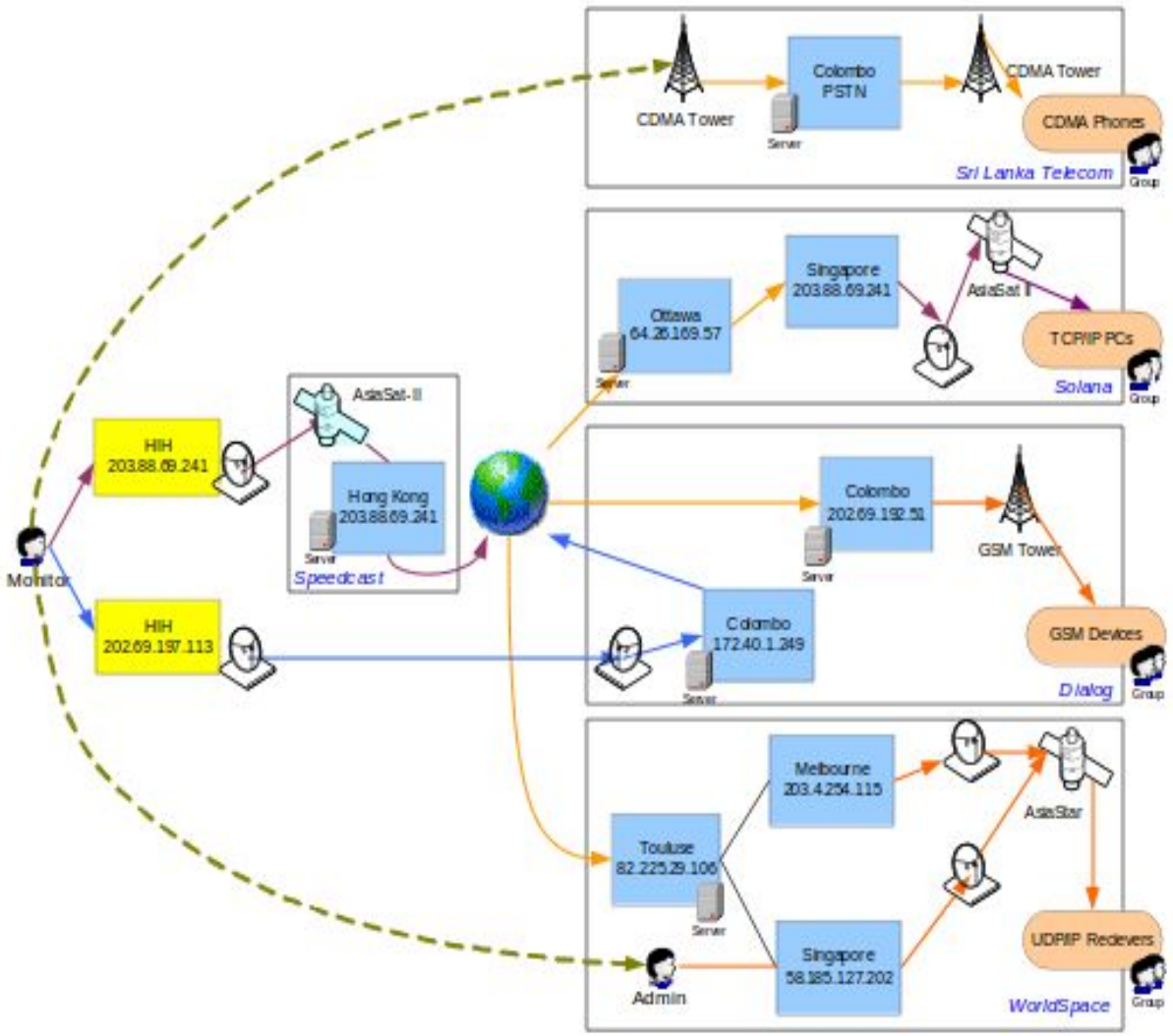


ICT infrastructure ecosystem
- is located in physical space
- it is powered by energy sources
- it is operated by people

Backhaul networks
[*issue*] :: wired & wireless public networks depend on domestic and international backhaul networks for effective functioning
[*remedy*] :: Competitive market approach to redundancy and business continuity (i.e. liberalized environments, multiple suppliers and technologies)

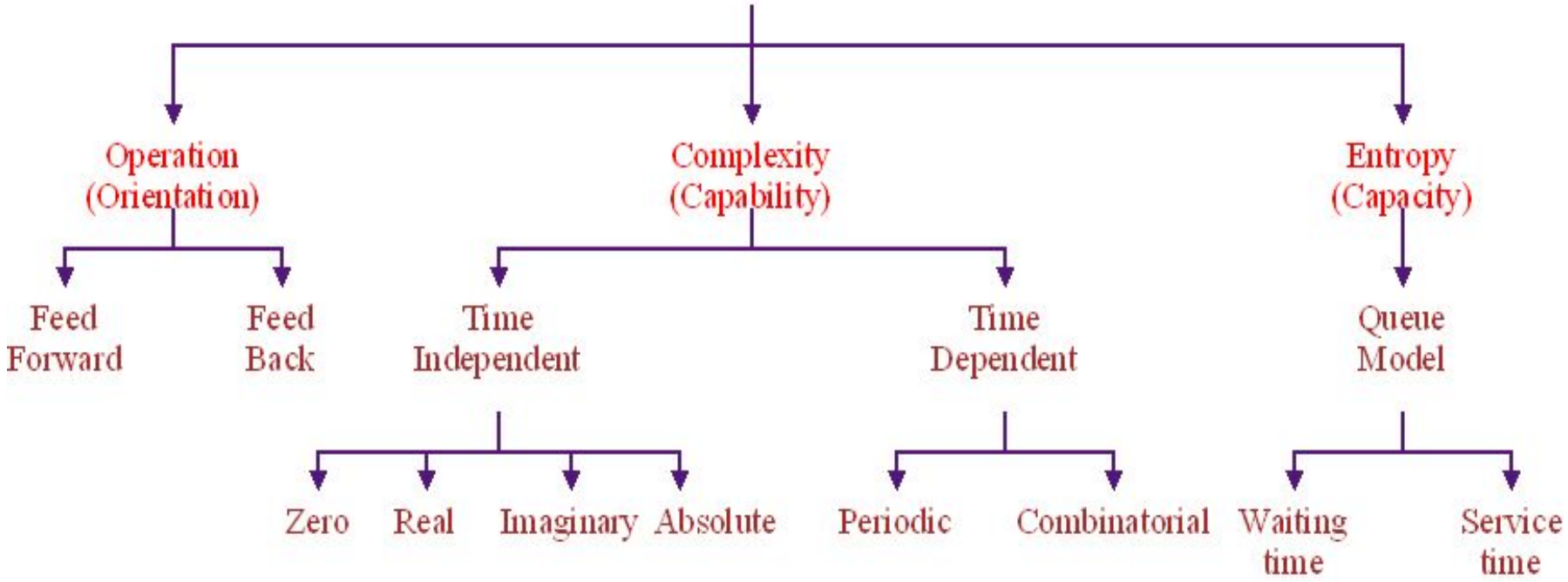
Congestion
[*issue*] :: consequences of congestion for first responders are extremely serious.
[*remedy*] :: is subscriptions to TETRA networks which are not interconnected to public networks

Example from HazInfo



- HazInfo Hub Monitors?
- ICT Service Providers - people, the links, antennas, interconnections, equipment, …?
- Community Emergency Response Teams?

Propositioned Classification Tree



- Operational orientation
  - Operations: sensing, detecting, deciding, brokering, responding (analogy: +, -, x, / in algebra)
  - Orientation: forward path or feedback (Inside or outside of the crisis window)
  - Before of after the tipping point
- Complexity of the system
  - Time independent complexity: zero, real, imaginary, & absolute
  - Time dependent: combinatorial & periodic
  - Synonymous with the physical part of the space or the domain the EWS exists in
  - Indicates the capability
- Entropy of expected state
  - Expected waiting time
  - Expected service time
  - Indicates the actual capacity

Thank You